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Edward C. Cantino, *University of Pennsylvania*

THE ETIOLOGY OF CROWN-GALL

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THE QUARTERLY REVIEW *of* BIOLOGY

THE MORPHOLOGY AND LIFE CYCLES OF TRYPANOSOMES

BY ELMER R. NOBLE

University of California, Santa Barbara College

INTRODUCTION

A recent examination of culture forms of *Trypanosoma cruzi* in my own laboratory disclosed a growing mass of actively motile flagellates the majority of which were without undulating membranes. This situation appeared to be contrary to most published reports, which state that motile forms in the invertebrate host and in culture are predominantly crithidiform (Fig. 6B), characterized by a kinetoplast located in front of the nucleus and an anterior, short undulating membrane. In our cultures a large number of metacyclic stages (see p. 9), characterized by a kinetoplast located at the posterior end of the body and by a long undulating membrane and short anterior flagellum, were always present, but mature crithidials were uncommon. It occurred to me that these metacyclic flagellates were probably derived from cells other than crithidials, and since the usual description of trypanosome life cycles states that metacyclic stages come from crithidials, a study of the evidence for the statement seemed desirable, and led to an expansion of the present article to include a review of the literature on the morphology and life histories of trypanosomes.

In 1936 Hoare (1936a) published an excellent outline of the classification of mammalian trypanosomes. This study was based on some earlier work of Hoare and Coutelen (1933). Part of Hoare's system of classification includes a consideration of life cycles. It is appropriate, therefore, to use this classification as a basis for the present review. *Trypanosoma zapi*, described in detail in 1952 by Davis, has been added to Hoare's list of examples. An early comprehensive review of the work on trypanosomes and trypanosomiasis is that of Laveran and Mesnil (1912), who discussed the classification and life cycles, but gave little consideration to the evolution of trypanosomes. The evolution of the group is discussed by Hoare and Coutelen (1933), by Hoare (1936), and by Grassé (1952). The following abbreviated description of trypanosomes in vertebrate hosts is modified from the original according to suggestions made by Dr. Hoare (1954) in a personal communication.

GENUS TRYPANOSOMA

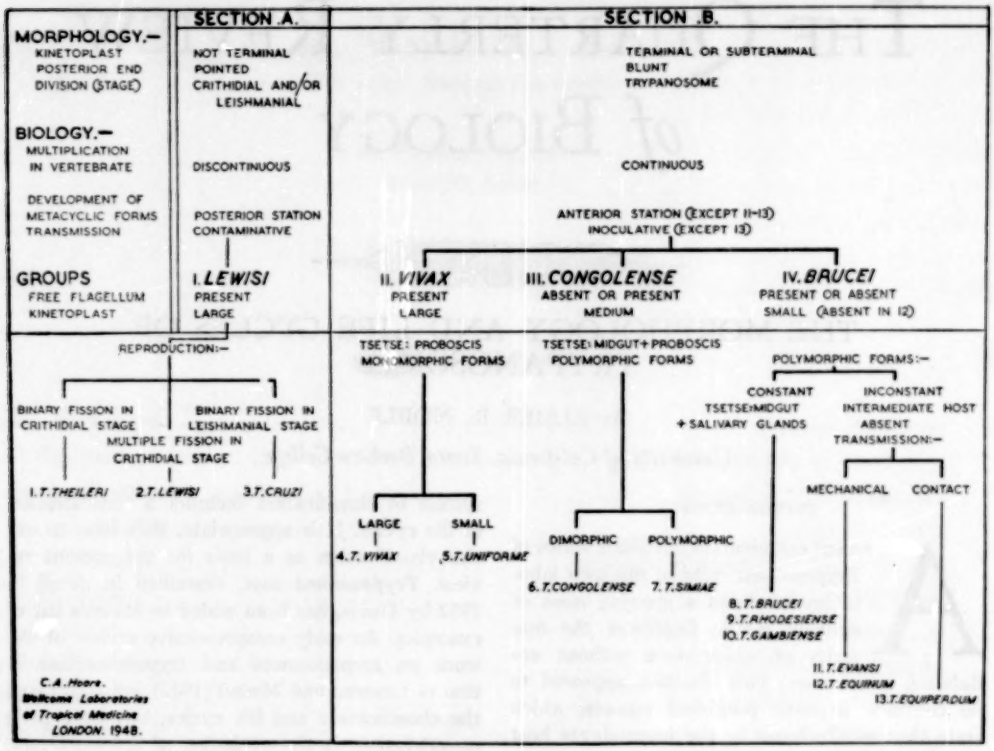
(Table 1; see Fig. 8)

Section A

Distinctive differences in methods of development among the species of the "lewisi group" of trypanosomes are to be found within the vertebrate hosts. This group is characterized by a drawn-out and pointed posterior end with a subterminal kinetoplast. Multiplication is discontinuous in the mammal, and division occurs typically in the leishmaniform and crithidiform stages. Diagnostic differences in the vertebrate host among those species of the "lewisi" trypano-

TABLE 1

CLASSIFICATION OF IMPORTANT MAMMALIAN TRYPANOSOMES



somes which have been described in detail are as follows:

T. pipistrelli (= *T. vespertilionis* ?)—reproduction by equal binary fission in the crithidial stage (Fig. 8A).

T. rabinowitschi (= *T. criceti*)—reproduction primarily by equal multiple fission and secondarily by binary fission in the crithidial stage (Fig. 8B).

T. theileri (? = *T. tragelaphi*, *T. ingens*)—reproduction primarily by unequal binary fission in the crithidial stage (occasionally division in the trypanosome stage). (Fig. 8C).

T. lewisi (Fig. 8D), *T. duttoni*, *T. primatum*, *T. zapi*—reproduction primarily by unequal multiple fission and secondarily by binary fission in the crithidial stage (occasionally division in the trypanosome stage). Multiple fission in *T. zapi* is restricted to a position within tissue capillaries.

T. cruzi—reproduction primarily by binary fission in the leishmanial stage and leading directly to the trypanosome without going through a crithidial stage (Fig. 8E). Occasional division in the trypanosome stage. Multiplication chiefly intra- and inter-cellular.

Section B

This section is characterized by a blunt posterior end and a terminal or subterminal kinetoplast. Multiplication is continuous in the vertebrate host, and division occurs typically in the trypanosome stage in the blood and lymphatic fluids. Significant differences in the life cycles among the species of this Section in the vertebrate host have not been described. Representative species are: *T. vivax*, *T. congolense*, *T. brucei*, *T. gambiense*.

THE CULTURE OF TRYPANOSOMES

A review of the physiology of trypanosomes is not within the scope of this paper, but some remarks on culture methods are appropriate because much of our information on the morphology

and life histories of trypanosomes has been gained from a study of culture forms. Little biochemical study of trypanosomes has been possible because of the difficulty encountered in the maintenance of many species in vitro. Cowperthwaite et al. (1953) have been the first to succeed in culturing a member of the family trypanosomidae [*Herpetomonas* (*Strigomonas*) *culicidarum*] in a completely synthetic medium. It is to be hoped that this work will lead to similar success with the species pathogenic to man.

The pathogenic forms are much more exacting in their requirements, especially the African species. Von Brand (1953) has pointed out that "although the metabolism of the bloodstream form of the African trypanosomes appears, from a purely formalistic standpoint, in some ways simpler than that of the culture forms, there can hardly be a doubt that the absence of certain enzymatic reactions in the former represents not an original condition, but is due to the loss of certain functions. That is, we are dealing with a specialization rather than with an original simple condition. This specialization may well be the reason that it has, so far, proven impossible to cultivate any trypanosome in the form it has in the blood stream of the definitive host." Some species of pathogens (e.g., *Trypanosoma equiperdum* and *T. congolense*) have been completely resistant to culture in vitro, and other species often develop strains which become far more difficult to culture than their parent strains.

The N. N. N. medium has been the most generally used medium for the maintenance of trypanosomes and leishmanias. It is prepared as follows: agar, 14 grams; NaCl, 6 grams; water (dist.) 900 ml. Mix, bring to boil, then distribute in tubes and sterilize in the autoclave. Cool to 48°C. and to each tube add ⅕ of its volume of sterile defibrinated rabbit blood. Mix well by rotating the tube, and cool in a slanted position on ice, if possible, in order to obtain as much water of condensation as possible. It is in this water that growth is most abundant.

We have found that *Trypanosoma cruzi* is easily grown in almost any medium containing mammalian blood. We have maintained cultures for four years in a diphasic medium consisting of human whole blood or red cell coagulum, agar, glucose, NaCl, and peptone. A few drops of blood are added to warm agar made up with the overlay solution, then cooled in a slanted position. The overlay solution is prepared according to the recommendations of Little and SubbaRow (1945) as follows: "Place 20 gm of bacto-peptone, 5 gm of NaCl c.p., and 2 gm glucose c.p. in a 2-liter Erlenmeyer flask. Add 1 liter of distilled water and dissolve without heating. Add 3 ml. of normal sodium hydroxide. The reaction should be pH 7.5." The solution is sterilized in an autoclave. The amount of overlay may vary from 1 to 5 ml. or the overlay may be omitted and trypanosomes plated directly on the blood-agar slant. Cultures are kept at room temperature and they are subcultured at approximately every three weeks, although maximum growth is occasionally reached in 7 days.

For *Trypanosoma gambiense* and *T. rhodesiense* an isolation medium described by Weiman (1946) is recommended for the culture of fresh strains from laboratory animals. The formula is as follows:

1. Base (autoclaved portion)

nutrient agar (Difco 1.5%, pH 7.3)	31 g.
distilled water to make	1000 ml.

Manufacturer's formula for Difco nutrient agar 1.5%: Beef extract 3 g.; Bacto peptone 5 g.; NaCl 8 g.; agar 15 g. to be dissolved in 1 liter of distilled water.

2. Non-autoclaved portion

human citrated plasma, inactivated (at 50°C. for 30 mins.)	12.5 ml.
human red cells	12.5 ml

Mix 25 ml. of the Base medium with 75 ml. of the non-autoclaved portion.

A satisfactory diphasic blood-agar medium for maintenance of *Trypanosoma gambiense*, *T. rhodesiense*, and other species is the one devised by Tobie et al. (1950) and made with rabbit blood and Locke's solution as follows:

Solid phase: Dissolve 1.5 g. Bacto-beef (Difco); 2.5 g. Bacto-peptone (Difco); 4.0 g. sodium chloride; and 7.5 g. Bacto-agar (Difco) in 500 ml. distilled water. Adjust the pH to 7.2–7.4 with NaOH and autoclave at 15 lbs. pressure for 20 minutes. Cool this mixture until it can be comfortably held in the hand (about 45°C.), then add whole rabbit blood, which has been inactivated at 56°C. for 30 minutes, in the proportion of 25 ml. blood to 75 ml. base.

FIG. 1. FIBRILS OF THE PERIPLAST AND FLAGELLUM AS DESCRIBED FOR TRYPANOSOMES BY SEVERAL AUTHORS

Coagulation of the whole blood is prevented by using 0.5 per cent sterile sodium citrate.

Liquid phase: Sterile Locke's solution of the following composition: NaCl, 8 g.; KCl, 0.2 g.; $CaCl_2$, 0.2 g.; KH_2PO_4, 0.3 g.; dextrose, 2.5 g.; and distilled water, 1,000 ml.

The base is dispensed in amounts of 5 ml. or 25 ml. into tubes or flasks, respectively. The test tubes are kept in a slanted position and the flasks upright until the base has solidified. Then the liquid phase is added in amounts of 2 ml. or 10 to 15 ml., respectively. The tubes and flasks are closed with cotton plugs which need not be capped since subcultures must be made before evaporation becomes serious. Human blood instead of rabbit blood can be used. Culture at 24° to 25°C. The peak of the population is usually reached in 10 to 14 days.

Trypanosomes may also be successfully grown in tissue cultures. See, for example, Kofoid, Wood, and McNeil (1935), and Hawkins (1946). For more precisely defined media containing known amounts of amino acids and vitamins see Little and Oleson (1951) for the culture of *T. cruzi*, and Hallman, Michaelson, and DeLamater (1950) for the culture of *Entamoeba histolytica*.

For detailed reviews of the nutrition of parasitic flagellates and the metabolism of the Trypanosomidae the reader is referred to the chapters by Marguerite Lwoff and by Theodor von Brand in Lwoff (1951); that by Theodor von Brand on "The Physiology of Blood Flagellates" (pp. 90–113) in Most (1951); and the symposium on *Growth of Protozoa* (Miner, 1953).

CYTOPLASM

The length of trypanosomes (including the flagellum) varies from about 12 to about 120 microns. They are generally spindle-shaped, flattened, and often spiral; but broad, leaf-like species are to be found, especially in the blood of fishes and reptiles.

With the use of a phase microscope the trypanosome flagellum is seen to be unlike a typical thread-like flagellum of the mastigophora. The flagellum of the trypanosome is a relatively stout anterior extension of the cell. Within, or along one edge of, this cytoplasmic extension is the axoneme, a filament arising from the blepharoplast. The undulating membrane arises first as an extension of the cell membrane along the base of the flagellum (see Fig. 6D), and the mature undulating membrane appears to be continuous with the body cytoplasm rather than merely with the cell membrane. For a review of work on protozoan flagella see Neuman (1926), Brown (1945), and Pitelka (1949).

Kleinschmidt and Kinder (1950) have found that the flagella of *Trypanosoma brucei* and *T. lewisi* from rats appear to be composed of groups of fibrillae. Microphotographs show these structures clearly. Kraneveld, Houwink, and Keidel (1951) have confirmed these findings with their electron microscopical study of *T. evansi*. Up to nine parallel isometric fibrils, each one 40–50 mμ, in diameter were counted within the flagellar cytoplasmic sheath (Fig. 1). The authors point out that if the cytoplasmic layer is the edge of the undulating membrane the flagellum is situated inside the membrane, "but if not, the flagellar bundle and cytoplasmic sheath together may represent one morphological entity and the undulating membrane another." There are also fine, 50 mμ-spaced cross striations along the flagellum, possibly indicative of contractility. Near its base the flagellum passes through a collar-like structure which presumably consists of reinforced periplast material. Lofgren (1950) demonstrated a similar structure, and with the use of the electron microscope he found that the flagellum appears to be laminated and made up of a bundle of filaments that are often fragmented longitudinally.

In a study of *Trypanosoma cruzi* with the electron microscope Meyer and Porter (1954) found that the axoneme, which alone extends into the distal portion of the flagellum, is composed of about 9 fibrils embedded in a matrix. The cell body and flagellum is bounded by a distinct pellicle 10 mμ thick. Subpellicle fibrils extend over the entire body and into the proximal portion of the flagellum. These fibrils show density variations, and they may be composed of spirally organized component structures. They can be digested with trypsin or by prolonged osmic acid fixation-re-

actions suggesting a protein composition. The authors suggested that the fibrils might be composed of finer fibrils arranged in a tight coil or spiral. They concluded that "it is reasonable to suppose that the fibers are contractile and are responsible for the tortuous motions of the blood-agar forms." Dense cytoplasmic granules in the cell body and in the flagellum were found to be lipid in nature.

By the use of the electron microscope Kleinschmidt and Kinder (1950) and Kraneveld et al. (1951) have found that the periplast of trypanosomes (*T. lewisi*, *brucei*, and *evansi*) contains longitudinal, nearly parallel fibrils (Fig. 1). These may be considered as longitudinal reinforcements of the cell membrane. The width of each fibril is estimated to be about 40 mμ, their number 60 to 80. The fibrils are thus seen to be of about the same width as those making up the axoneme of the flagellum. Lofgren (1950) described similar longitudinal striations in autolyzed "ghost" cells of *Leishmania tropica*. The striations "appeared to be heavy fibrils contained in a thin, elastic membrane."

Myonemes have been said to be present within the cytoplasm of trypanosomes. Jírovec (1933), for example, described such structures in *Trypanosoma rotatorium*. He used Klein's (1930) dry silver technique. Laird (1951) has recorded the presence of myonemes in the cytoplasm of trypanosomes in several species of fish. Longitudinal striations visible in light microscopes have generally been considered as contractile fibrils, but there is no evidence that they perform this function. Kraneveld et al. (1951) have pointed out that the submicroscopic fibrils represented in the electron microscope should not be confused with the striations visible in light microscopes. The electron microscope does not reveal coarser structures comparable with "myonemes."

Cytoplasmic inclusions present in trypanosomes are: vacuoles, granules of several types, mitochondria, the blepharoplast-kinetoplast complex, and the nucleus (Fig. 2). Details of the nuclear structure will be found in the section on cell division (p. 7). The other inclusions will be described briefly below.

Lavier (1928a) found in trypanosomes of the *Trypanosoma brucei* group a vacuole ("prebasal" vacuole) situated immediately in front of the kinetoplast. He suggested a secretory function of this vacuole. The same author (1928b) described paravacuolar formations in the cytoplasm of these flagellates. The formations were conceived to be fluid in nature, and clustered around the prebasal vacuole and nucleus. According to Lavier the paravacuolar formations are resistant to acids, a fact indicating their relationship to nucleoproteins. They are most apparent in trypanosomes whose vitality is attenuated, and they are perhaps the result of secretions from the prebasal vacuole. Van Hoof, Henrard, and Peel (1944) found that striking differences in vacuoles, flagella, grouping, etc., enable one to distinguish between the different species of trypanosomes that infect mammals, by examining fresh salivary glands of *Glossina palpalis*.

In most papers on trypanosomes, when cytoplasmic granules are mentioned at all, they are referred to as "volutin" or "metachromatic" granules. Little attention has been paid to them. They contain ribonucleic acid, and they are often concentrated at the posterior end of the cell, or, in developmental forms, between the nucleus and the kinetoplast. Van den Berghe (1946) pointed out that ribonucleic acid is found characteristically in the cytoplasm of all embryonic cells and of all very active adult cells. It undoubtedly plays an important role at certain stages in the development of the cell. Van den Berghe (1942) found that the volutin granules in the cytoplasm of *Trypanosoma evansi* and *T. gambiense* disappear after subjection to the action of ribonuclease. By the use of a less active ferment and by varying the duration of the digestion, the granules are reduced gradually in size, an observation which suggests that the disappearance of the staining reaction is related to a progressive destruction of ribonucleic acid.

Scattered through the cytoplasm are lipoid spherules (identifiable by their reactions to the "fat" stains), Golgi granules situated near the

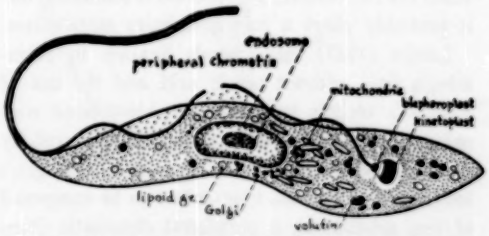


FIG. 2. A DIAGRAMMATIC REPRESENTATION OF A TYPICAL TRYPANOSOME SHOWING CYTOPLASMIC INCLUSIONS

nucleus, and mitochondria. Mitochondria have been identified in trypanosomes by a number of authors. These bodies are stainable by the methods commonly used for other kinds of cells (e.g., Altmann's acid fuchsin). Wotton (1940) found no essential morphological variations in the mitochondria among five species of trypanosomes studied. Mitochondria in trypanosomes probably function in relation to the synthesis of secretion products, as in higher animals. Wotton's studies on *Trypanosoma lewisi* suggest a mitochondrial function related to fat metabolism. The mitochondria appear as slender rod-shaped bodies, generally few in number (up to 12), and usually lying parallel to the long axis of the cell.

Cytoplasmic inclusions which are not generally observed are pigment granules (black or greenish) such as have been described for many trypanosomes of fish, and filaments from the blepharoplast. The functions of these structures are unknown. A fibril from the blepharoplast extending anteriorly or posteriorly, or possibly to a centrosome within the nucleus has been described by Kraneveld et al. (1951). A. and M. (and M. and A.) Lwoff (1931; 1931) have demonstrated a "parabasal filament" and paranuclear body in *Leptomonas;* these, or similar, organelles have also occasionally been claimed to occur in the genus *Trypanosoma*.

The kinetoplast, measuring ±1 micron in diameter, lies adjacent to the blepharoplast or basal granule which is the starting point of the flagellum. The kinetoplast has frequently been called a parabasal body (see reviews by Hoare, 1954; Kirby, 1944), in spite of the fact that the former body does not arise de novo, whereas the parabasal body disintegrates during cell division (in some higher flagellates) and is reformed in the daughter cells (see Grassé, 1952). The kinetoplast reproduces itself by independent, equal division when the cell divides. Its function is unknown, but it probably plays a role in cellular metabolism.

Lavier (1927) recommends fixation in Flemming's fluid without acetic acid and the use of Regaud's technic to render the kinetoplast conspicuous. A mitochondrial nature is suggested by the kinetoplast's reaction to vital stains. Feulgen's technique reveals the kinetoplast to be composed of two substances, a peripheral chromatic (thymonuculeic acid) cortex or ring, and a central achromatic mass.

As early as 1910 Werbitski found that trypanosomes without kinetoplasts could be obtained by treating them with pyronin. Since that time numerous papers have been published on akinetoplastic strains (see the reviews of Hoare and Bennett, 1937, 1938). Other organic dyestuffs, such as acridine, oxazine, and trypaflavin also effect a loss of kinetoplasts (see Piekarski, 1949), but this organelle may be absent in a small percentage of the individuals of a normal population. Thus in the *T. brucei-evansi* group the number of akinetoplastic flagellates may reach 10 per cent, while in the *T. vivax* and *T. congolense* groups it does not exceed 0.8 per cent. In other strains (e.g. *T. gambiense*) the percentage may fluctuate up to almost 100 per cent akinetoplastic (see Jírovec, 1931). Aberrant strains (e.g., *T. evansi* and *T. equiperdum*) have been known to occur spontaneously in normal populations. One species, *T. equinum*, of South America, totally lacks a kinetoplast, but it is otherwise indistinguishable from *T. evansi*. Wenyon (1928) suggested that *T. equinum* originated from an akinetoplastic strain of *T. evansi*. Hoare (1954) has pointed out that "if this hypothesis is correct, *T. equinum* provides a rare example among the protozoa of the formation, under natural conditions, of a new species, the origin of which by mutation from the parent-species (*T. evansi*) can be traced."

For some unknown reason the kinetoplast may fail to divide during mitosis, with the result that one daughter cell is devoid of this body, and continues to breed true. This may lead to a fluctuating strain in which there is a struggle for existence between the normal and the akinetoplastic forms, or to a totally akinetoplastic strain such as is found in those species which are transmitted mechanically (e.g. *T. evansi*, *T. equiperdum*, *T. equinum*) without cyclical development in an invertebrate vector. Hoare (1954), in a review of the entire problem, has regarded the loss of the kinetoplast as comparable to the loss of plastids in phytoflagellates. In a discussion of the genetic aspects of this phenomenon Hoare has regarded it as a mutation determined by plastogenes, for the mutant trypanosomes appear, breed true, and give rise to a new race. In an earlier paper Hoare (1940) pointed out that the akinetoplastic condition can be interpreted as the result either of mutation depending upon changes in the chromosome constitution, or of cytoplasmic inheritance independent of the nucleus.

CELL DIVISION

During the past fifty years over 200 papers dealing with cell division in trypanosomes have been published. The most recent review of this process in the genus *Trypanosoma* is that of Noble et al. (1953). Grassé (1952) has discussed in detail life histories and cell division in all the Trypanosomidae. Our observations confirm the abundant evidence that at the start of division the blepharoplast divides and the original flagellum remains attached to one of the daughter blepharoplasts. At the same time the kinetoplast also divides by a simple pinching into two parts.

According to Noble et al., "cell division in culture forms of *Trypanosoma cruzi* begins with the migration of the kinetoplast to a position close to the nucleus and to the cell membrane. As the kinetoplast divides, a cytoplasmic division in the form of a small lateral projection of the body becomes evident. Peripheral chromatin in the nucleus moves to its center and three chromosomes are formed. The lateral projection enlarges to give the appearance of two trypanosomes united at their posterior ends. The nucleus divides mitotically. The daughter cells, still united at their posterior ends, rapidly straighten in opposite directions, giving the appearance of a single elongated cell with two nuclei and with a flagellum at each

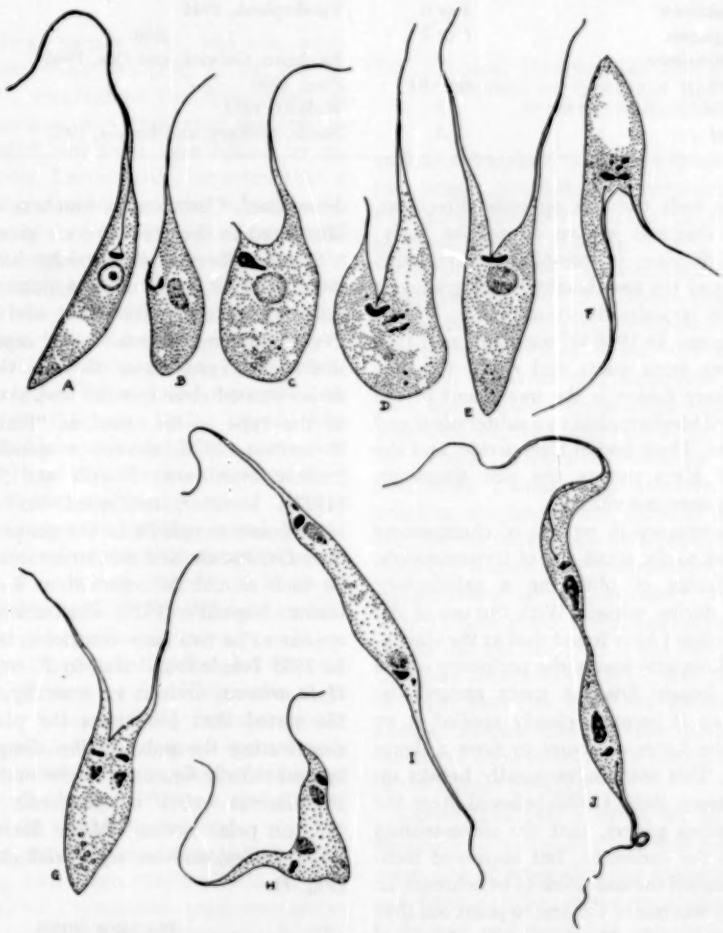


FIG. 3. STAGES IN CELL DIVISION OF *TRYPANOSOMA CRUZI*

G shows two sets of three chromosomes. I does not show the diagonal groove along which final separation of daughter cells takes place. Rearranged from Noble *et al.*, 1953. (Courtesy of *Trans. Amer. micr. Soc.*)

TABLE 2

The Reported Chromosome Numbers of the Trypanosomidae

Species	Number of Chromosomes	Author and Date
T. brucei	8	Prowazek, 1904
T. vespertilionis	8	Gonder, 1910
T. chagasi	5	Horta and Machado, 1911
T. dimorphon	10?	Hartmann and Nöller, 1918
T. cruzi	10?	ibid.
T. theileri	4 or 5	ibid.
T. equiperdum	3	Roskin and Schischliaiewa, 1928
T. brucei	3	ibid.
T. rhodesiense	3	ibid.
T. surra	3	ibid.
T. pecaudi	3	Roskin and Schischliaiewa, 1929
T. suaura	3	ibid.
T. gambiense	3	ibid.
T. rhodesiense	5 or 6	Vanderplank, 1944
T. congolense	6 or 7	ibid.
T. rhodensiense	6	Fairbairn, Culwick, and Gee, 1946
T. cruzi	6 to 10	Pizzi, 1950
T. lewisi	3	Wolcott, 1952
T. cruzi	3	Noble, McRary, and Beaver, 1953

end. The two ends twist in opposite directions, producing a diagonal groove along the body. Cytoplasmic division is completed along this diagonal line and the two daughter cells gradually move apart in opposite directions." Fig. 3 illustrates this process. In 1948 Wilson also found that in *T. uniforme* from goats and sheep the first change in binary fission is the movement of the kinetoplast and blepharoplast to a subterminal and lateral position. These bodies then divide, and the posterior half gives rise to the new flagellum. Chromosomes were not visible.

A wide discrepancy in reports of chromosome numbers is due to the small size of trypanosomes, and the difficulty of obtaining a satisfactory nuclear stain during mitosis. With the use of the Feulgen technique I have found that at the start of mitosis the chromatin leaves the periphery of the nucleus and loosely fills the space around the endosome; then it becomes closely applied to or mixed with the latter structure to form a dense central mass. This mass subsequently breaks up into chromosomes. Bělař (1926) believed, from the study of previous papers, that the chromosomes develop from the endosome, but improved techniques have proved the endosome to be achromatic. Jírovec (1929) was one of the first to point out that the chromatin is confined to the peripheral layer of the nucleus and that the endosome is of plastin material similar to the nucleoli of metazoan cells. The fate of the endosome, however, has not been determined. Chromosome numbers as reported or illustrated in the literature are given in Table 2.

Spindle fibers and centrioles have frequently been reported, both often appearing within the nuclear membrane. Hartmann and Nöller (1918) illustrated large, pointed polar caps and spindle fibers in *Trypanosoma theileri*. Gonder (1910) demonstrated clear spindles and heavy polar caps of the type to be found in "limax" amoebae. Robertson (1927) showed a spindle within the nuclear membrane. Roskin and Schischliaiewa (1928), however, concluded that there is no centrosome or spindle in the genus *Trypanosoma* or in *Leishmania*, and that structures purporting to be such should be regarded as karyoplastic remains. Nigrelli's (1929) illustrations show what appear to be two large centrioles, but no spindle. In 1935 Ivanic found that in *T. rotatorium*, from *Hyla arborea*, division is, typically, a promitosis. He stated that sometimes the plastin material constituting the polar bodies disappears, giving typical mitotic figures. The chromatin material of the nucleus exists independently of the large "plastin polar bodies." Many fibers connect the polar bodies, and an equatorial plate is formed (Fig. 4).

POLYMORPHISM

Most reports on the morphology of trypanosomes from the blood of vertebrates describe three body types—a short, broad form, often without a

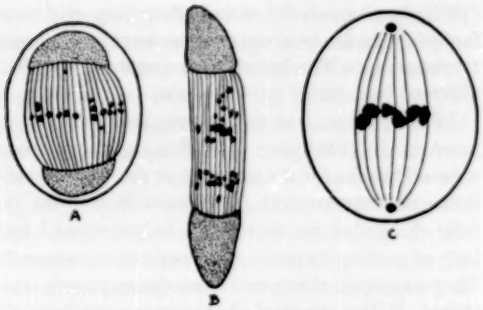


FIG. 4. MITOSIS IN TRYPANOSOMES

A and B, showing "plastin polar caps" and numerous chromosomes of *Trypanosoma rotatorium*. Adapted from Ivanic, 1935. C, metaphase with centrioles within nuclear membrane, as described by many authors.

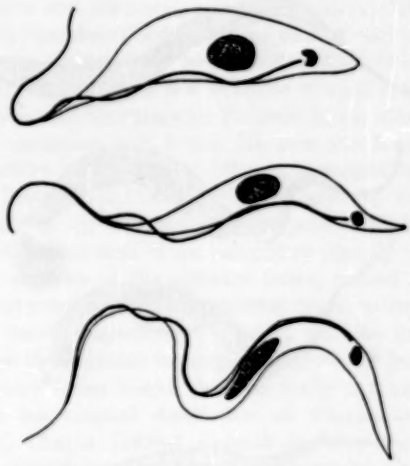


FIG. 5. LARGE, INTERMEDIATE, AND SLIM FORMS OF TRYPANOSOMES AS COMMONLY REPORTED FROM VERTEBRATE BLOOD

flagellum; a long, narrow form; and one intermediate between these two (Fig. 5). M. and P. Delanöe (1912) emphasized the dimorphism of blood trypanosomes, and they were the first to express the belief that these were related by intermediate forms. Lavier (1933) reported that a strain of *Trypanosoma brucei* carried in mice for 35 years still showed 2 of the dwarf forms per 1000 parasites. The same condition was noted in the reputedly monomorphic *T. evansi* and *T. equiperdum*, although the dwarf forms did not exceed 1 in 2000. In the arthropod hosts all developmental stages from leishmaniform bodies to the three trypanosome types have been reported (see Morishita, 1928; Carpano, 1932). All of these body types have been observed in our cultures of *T. cruzi* (Fig. 6), and they have been reported from the cultures of other species by several authors. Evidence was presented by Muniz and Freitas (1946) that the slender forms with elongated nuclei are the first to appear in cultures of *T. cruzi*.

One of the body forms of *Trypanosoma cruzi* in the insect host is long, slim, and very active. It has been called a "metacyclic" stage by Brumpt (1913), and is presumed to be the infective stage for vertebrates. Chagas (1927), however, interpreted this form as representing an asexual multiplication of the "male" in the blood of the insect digestive tract. See pages 21–26 for a discussion of the problem of sex in these parasites.

In our cultures the leptomonad type is the most abundant (Fig. 6A). Davis (1952) also found that crithidial forms (of *Trypanosoma zapi*) were not as common in cultures as were the leptomonads. The metacyclic stages in cultures of *T. cruzi* are long and slim, pointed at both ends and with short flagella. These stages in other species have been variously described. Short and Swaminath (1931), for example, found that the metacyclic forms of *T. phlebotomi* are 2–3 microns in diameter, and spherical or ovoid in shape.

One of the early efforts at cultivation of trypanosomes was that of Thomas (1908), who observed that the long narrow forms in the blood of the goldfish became broad and shorter when cultured. Thomson and Robertson (1926) noted that when either *Trypanosoma rhodesiense* or *T. gambiense* was transferred from one species of host to another it became markedly polymorphic. Continued transmission, however, resulted in practical monomorphism, the final type being the long slender form. Some different conclusions were drawn by Corson (1936), who stated that repeated transmissions of *T. rhodesiense* and *T. brucei* through rats, goats, sheep, guinea pigs, birds, and *Hyrax* did not result in a loss of polymorphism. One may conclude, however, that initial transfers of these parasites from one species of host to another species stimulate the development of a variety of body forms of the trypanosomes as part of the normal life cycle.

Lavier (1942–43) studied the problem of the evolution of morphology in the genus *Trypanosoma*, and he recognized five morphological types, as follows: (1) the oldest type with a long, slender body and well developed undulating membrane; the kinetoplast situated at some distance from the posterior extremity; occurring in fishes, urodeles, and chelonians; (2) an enlarged body, with dis-

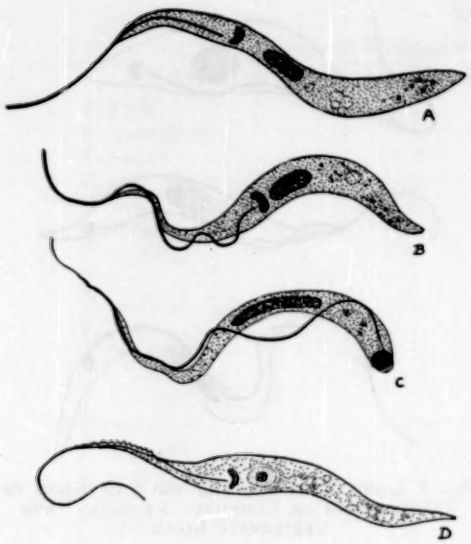


FIG. 6. MOTILE FORMS OF *TRYPANOSOMA CRUZI* AS SEEN IN CULTURE

A, young crithidiform ("leptomoniform"). B, crithidiform. C, trypanoform with large terminal kinetoplast. All three from stained (Giemsa) culture smears. D, young crithidiform stage showing beginning of undulating membrane, from living preparation as seen with the phase microscope.

placement of the kinetoplast anteriorly and of the nucleus posteriorly; in anura and reptiles, and extending into birds and mammals; (3) with an exaggeration of enlargement leading to globular forms; in anura and reptiles; (4) with a thick, large, median nucleus, and kinetoplast somewhat distant from the posterior extremity; in birds; (5) derived from type 4 by becoming thinner; kinetoplast less displaced anteriorly, nucleus with a tendency to a more anterior position; in mammals. Lavier regarded the pathogenic species in mammals as aberrant, having only juvenile forms which are morphologically simple, and divide indefinitely.

Culwick and Fairbairn (1947) showed that *Trypanosoma simiae* in pigs is consistently trimorphic. Metacyclic forms are also present, and many of these are apparently without free flagella. Lewis and Langridge (1947) also reported the presence of metacyclic forms (of *T. brucei*) without free flagella in the "saliva" of tsetse flies. It is of interest to note that Fairbairn and Culwick (1949) have differentiated *T. gambiense* by its smaller metacyclic forms as compared with those of *T. rhodesiense* and *T. brucei*. Culwick et al. (1951) have produced some interesting evidence for hybridization between two species of pathogenic trypanosomes. The hybrids were morphologically different from either parent strain.

In a discussion of sex in trypanosomes Fairbairn et al. (1946) gave a possible explanation, on a genetic basis, for the presence of the three blood forms of *Trypanosoma rhodesiense*. Where sex is fully developed an association is maintained by lack of pairing between the "sex chromosomes." They suggested that two chromosomes remain unpaired. If the unpaired chromosomes are labeled A and A′, a combination of these would provide the three types AA, AA′, and A′A′. The authors believed that the long, thin forms must have the combination AA′ because they are the only ones which reproduce readily by binary fission; and because the other two types are produced from them by syngamy, they must contain both types of chromosomes. The authors also believed that the vigor which the AA′ form displays is consistent with heterosis. If this conclusion is correct, the short and intermediate forms can only be AA and A′A′.

The only general conclusion which can be made about the published descriptions of body forms of trypanosomes is that the various authors agree that at least three forms exist in the blood of vertebrates. There is little unanimity on the relationships among these body types. The terms "slim," "fat," "rounded," etc., appear frequently, but since they are entirely relative in their meaning they are of little value in the determination of the concept of a life cycle. Such terms should be accompanied by detailed cytological descriptions.

LOCOMOTION

We found that *Trypanosoma equiperdum* in guinea pig blood moves forward along an irregular path, and it occasionally exhibits the ability to spring backward or sideways. This species did not move in the manner most commonly observed in culture forms of *T. cruzi*, as described below.

The forward movement of a leptomoniform stage of *Trypanosoma cruzi* progresses in an approximately straight line for a period of 2 to 10 seconds (at 21° C.); then it suddenly stops, and the flagellum reverses the direction of its undulations to lash out more slowly from its base, while the body jerks so as to shift its position. Then the flagellar undulations begin at the anterior tip again, and the individual moves forward in a new path, soon to

repeat the change of direction. Metacyclic stages in locomotion move so rapidly that they appear to vibrate. The whole body behaves like an undulating membrane. Davis (1952) mentioned that *T. zapi* in blood "appears to move forward propelled by undulations of the body anterior to the kinetoplast and by the pulling action of the rapidly beating flagellum; the part of the body posterior to the kinetoplast remains still and unbending. To reverse direction when moving rapidly, the anterior end loops quickly over the posterior end, which then jerks back into position."

When placed on a slide most of the leptomoniform and crithidial stages of *Trypanosoma cruzi* are actively moving. The tip of the flagellum generally becomes attached to the glass, and often there is a violent thrashing about as if the cell were struggling "to get free." Such attachment was found to be equally abundant on unwashed slides, paraffin-coated slides, and on slides which had been scrupulously cleaned. Often a subterminal spot on the flagellum appeared to be attached instead of the tip, and occasionally the posterior end of the body was "stuck" to the slide. When the trypanosome is not moving forward and is not attached to the glass, it sometimes exhibits a series of violent contortions.

The "sticking" phenomenon may well be correlated with a difference in electric charge between the cell and its substratum. Broom, Brown, and Hoare (1936) showed that positively charged *Trypanosoma brucei* tended to adhere to the negatively charged red blood cells, while a negatively charged strain of *T. cruzi* remained free from the red cells. Fairbairn, Culwick, and Gee (1946) noted that a positively charged strain of slender forms of *T. rhodesiense* adhered to red cells, while a negatively charged variant remained free. Wood (1953) reported adherence of positively charged, slender forms of *T. cruzi* to negatively charged red cells in a sodium citrate solution, the agglutination "thus checking their progressive movements."

SEX IN TRYPANOSOMES

Ziemann (1902) was the first to point out the possibility of the existence of sex in trypanosomes. Since that time most investigators have been unable to produce convincing evidence of its presence, although from time to time a paper appears which claims to have rediscovered gametes in vertebrate or arthropod hosts, or in artificial cultures. Schaudinn (1904) mentioned microgametes and oökinetes, and a reduction division of the "parabasal bodies" at the time of conjugation in *Trypanosoma noctuae*. Prowazek (1904, 1905) felt certain he saw evidence of a reduction division and autogamy in *T. lewisi* in rat blood, and copulation in *T. brucei*. His male and female flagellates were markedly different in morphology, but Prowazek did not actually see fusion of their nuclei. In his description of *T. grayi*, Minchin (1908) stated that "I am inclined to identify the two varieties of the ordinary forms, termed . . . the serpentine and the vermiform types, as male and female respectively . . . but it must be confessed the evidence is meagre. Some of the large ordinary forms might then be really zygotes."

In his original description of *Trypanosoma cruzi*, Chagas (1909a) claimed to have found sexually differentiated forms in the insect host, and in 1911 he concluded "that schizogony of *S. cruzi* in man and laboratory animals represents a multiplication of sexual forms and is consequently a gametogony." His arguments in favor of a sexual process, however, are not convincing, and his illustrations do not support his interpretations.

Hindle (1909) described three distinct types of *Trypanosoma dimorphon* from horse blood: (1) an indifferent type, from which the other two arise; (2) long males; and (3) stumpy females. He says, however, "the evidence for regarding the latter two as sexual forms is inconclusive since we have never observed conjugation." In 1911 Kleine and Taute described long, slim, active male and stouter female forms of *T. gambiense* and *T. brucei* in the gut of flies. Mayer (1913) reviewed the research of this problem and concluded that the occurrence of sex forms of these flagellates in insects and in warm-blooded hosts was well established.

In 1916 Swezy summarized the evidence of the existence of sexual development in trypanosomes as follows: "The solution of the question of sexually differentiated gametes and of syngamy in these forms has thus far proven elusive, and the recorded occurrences of bisexual gametes and sexual reproduction, as in the case of *Trypanosoma lewisi* as recorded by Prowazek (1905), may be received with much skepticism. The fact that it has not been found beyond dispute is not, of course, conclusive evidence against its occurrence, but it is conclusive evidence in so far as the so-called nuclear behavior of the parabasal body during conjugation is concerned. The well-known instance

described by Schaudinn in '*Trypanosoma*' *noctuae*, cited by Hartmann, is very plainly the result of a peculiar arrangement of pigment granules so common in these forms."

After Swezy's paper appeared, no reports of sexual stages in the genus *Trypanosoma* were published until that of Chagas in 1927. He described, from vertebrate blood, slender, active males and larger, less active females of *T. cruzi*. In *Triatoma megista* forms representing the blood-dwelling gametes were observed in sexual union. Chagas suggested, but he did not prove, that these zygotes may give rise by multiple division to the slender specimens found singly or in rosettes in the insect mid-gut. Muniz (1927) observed the usual two types of flagellates in cultures of *T. cruzi*. He thought that the slender ones with more compact nuclei were "probably" males and the others females. One case was described in which a small cell made contact with a large one, and this phenomenon was thought to be a sexual process. Neither his arguments nor illustrations are convincing.

We have repeatedly found that the cells in both living and stained preparations are frequently in fortuitous parallel contact with one another. We believe that the earlier authors made the mistake of labeling as males the slim, active metacyclic forms which commonly dart among the stouter, less active stages.

Elkeles (1940, 1944, 1945), in his studies of *Trypanosoma cruzi*, revived the arguments in favor of the presence of a sexual development in trypanosomes. At first he found stages which "probably" represented sexual union, and he thought that a sexual process could not be ruled out. Later he concluded that "biological considerations, observations of Adie (1921) and Muniz (1927) and my own investigations support the original idea of Chagas that sexual processes do occur." In his 1940 paper Elkeles figured a probable sexual union which looked very much like his photomicrograph of a stage in longitudinal division. T.-W.-Fiennes (1945) added to the renewed interest in the possible existence of sex in trypanosomes by his statement that in mouse blood diluted with an equal amount of 0.3 per cent NaCl, sexually mature forms of *T. congolense* quickly became microgametes and macrogametes, and conjugated to produce motile zygotes. The zygote changed into an amorphous oocyst, seen in skin sections and in the lung of a calf, and then it developed into a sporoblast and sporozoites. It is unfortunate that the author did not include illustrations in his report.

Vanderplank (1944) suggested a mechanism of fertilization by gametes extruded from one trypanosome and entering another. He worked with *Trypanosoma rhodesiense* and *T. congolense*, and he found that in both species there were two types of individuals differentiated on the basis of their chromosomes. In each case one of the two types of flagellates possessed an unpaired chromosome. Vanderplank thought it likely that meiosis takes place, the unpaired chromosome acting like sex chromosomes of other animals. He never actually observed the union of "gametes."

The most recent support of the belief in the presence of a sexual process comes from the papers of Fairbairn and his associates. In 1946 Fairbairn et al. felt that Vanderplank's conclusions cannot be valid unless we are prepared to postulate two entirely different methods of syngamy in the same organism, which is more than unlikely. They go on to say, "Syngamy in *T. rhodesiense* is not a typical copulation in which two gametes unite completely. In the first place, each one of the fusing pair retains its own identity to some extent throughout the process, and secondly, since one form of the normal trypanosome with six chromosomes exhibits heterosis, N = 6 must represent the diploid phase of the organism, and hence the fusing pair cannot be considered as gametes." Syngamy was observed in *T. rhodesiense* and in *T. simiae*, occurring only between cells carrying opposite electrical charges. Syngamy is not typical, since each of the fusing pairs retains its own identity throughout the process. Syngamy is inducted by a marked change in environment and is part of an adaptive mechanism. It occurs in a "head-to-tail" fashion. A study of the authors' illustrations leads me to question this interpretation because in each case the figures representing sexual behavior are practically identical to figures in numerous other papers and to our own illustrations representing varieties of fission or of agglomeration. Fairbairn et al. apparently use the coexistence of one nucleus and two flagella as their chief evidence for syngamy. They admit that their Fig. 32, for example, "may be an abnormal type of division in a short form," but it is suggested that it illustrates syngamy in the "head-to-tail" position.

It should be recalled that Hoare (1936b) described a similar kind of union, but he called it

"auto-agglutination" or "agglomeration." He emphasized that no nuclear changes have been observed and hence the process should not be interpreted as a sexual one. Also, as long ago as 1914 Bruce et al. considered such "head-to-tail" fusion of *Trypanosoma simiae* as an aberrant type of division.

We have found numerous paired immature crithidial forms in close contact. Most of these have been shown (Noble, McRary, and Beaver, 1953) to be stages in mitotic division, but upon several occasions two individuals were seen with the phase microscope to be slowly swimming together in a "head-to-tail" union. An occasional sliding along the plane of contact proved the pair to be temporarily united, but there was no evidence of an exchange of nuclear material. True nuclear fusion may very well take place in the trypanosomes, but until such fusion is actually observed, we are reluctant to admit that it has occurred.

LIFE CYCLES

We have maintained *Trypanosoma cruzi* in culture during the past five years. Starting in March of 1949 with a strain isolated from a human patient in Costa Rica by Dr. Herbert Johnstone, the cultures have been grown predominantly in an inorganic medium described by Little and Subba-Row (1945), with the addition of peptone and a coagulum of hemoglobin. For details of the preparation of this medium see p. 3 (see also McRary, Beaver, and Noble, 1953; Noble, McRary, and Beaver, 1953). Approximately 85 subcultures have been made, each after a growth period of about 3 weeks.

Most of the trypanosomes in our cultures have long flagella without clearly defined undulating membranes. Metacyclic forms are always present and number up to 50 per cent of the total flagellates. A small number of leishmaniform bodies lie on the bottom of each culture, and sometimes these bodies are present in large agglutinated masses, but mature crithidial stages have been consistently difficult to find. The flagellated forms maintain their numbers chiefly by mitosis (see Noble, McRary, and Beaver, 1953). The motile forms are flattened like a ribbon, and undulations during locomotion are usually confined to the parts anterior to the nucleus except in metacyclic individuals. In older cultures (e.g., 6 weeks old) the posterior tip of the body is sometimes bifurcated,

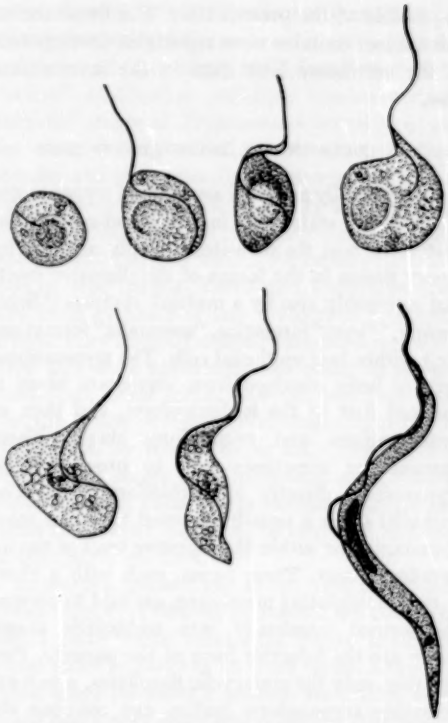


FIG. 7. SUCCESSIVE STAGES IN THE PROGRESSIVE DEVELOPMENT OF A TRYPANOSOME (*T. CRUZI*) FROM A LEISHMANIFORM CELL

The metacyclic stage (lower right) is from a stained (Giemsa) smear; the others are from living preparations of culture material as seen with the phase microscope.

the bifurcations occasionally being drawn out into threads resembling flagella.

The numerous metacyclic forms in culture appear to be derived by a direct development from leishmaniform bodies. Fig. 7 illustrates the method of this development as seen in both stained and in living material. This type of growth, in which the flagellum from one side of the cell grows over the surface to extend from the opposite side of the cell, has been described or figured by Regendanz (1929), Carpano (1932), Whitaker (1933), Romaña and Meyer (1942), Elkeles (numerous papers), Muniz and Boriello (1945), Muniz and Freitas (1946), Lewis and Langridge (1947), Wood (1951), and Davis (1952). See the following pages for details of these reports.

We have used our observations on trypanosome development in vitro and in the gut of infected triatomid bugs to aid in the presentation of as complete an account of trypanosome life histories

as possible at the present time. The literature on this subject contains more reports on development in the vertebrate host than in the invertebrate host.

THE CYCLE IN THE INVERTEBRATE HOST

The generally accepted accounts of trypanosome life histories state that in the blood-sucking invertebrate host the parasites multiply actively by binary fission in the lumen of the digestive tract, and commonly also by a multiple division ("Schizogony," "cyst" formation, "somatella" formation, etc.) within host epithelial cells. The trypanosome type of body obtained from vertebrate blood is changed first to the leishmaniform, and then to leptomoniform and crithidiform stages. These changes are sometimes said to progress from trypanoform directly to crithidiform cells. The crithidial stage is usually reported to be the most abundant type within the digestive tract of the invertebrate host. These forms, each with a short anterior undulating membrane, are said to become transformed eventually into metacyclic stages which are the infective form of the parasite. Presumably, only the metacyclic flagellates, which are immature trypanoform bodies, can continue development in the vertebrate host.

Minchin and Thomson (1915) outlined a process of asexual multiplication ("sporulation" or "schizogony") during the life cycle of *Trypanosoma lewisi*. Parasites ingested from a rat by the flea actively multiplied in the mid-gut, then penetrated epithelial cells. Each flagellate became enlarged, rounded, and "divided up within its own periplast into a number of daughter individuals, which writhe and twist over each other like a bunch of eels within the thin enevelope enclosing them." The periplast finally burst, liberating about 8 trypanosomes, which escaped into the lumen of the mid-gut. This type of multiplication is similar to that described from vertebrates by Chagas (1911) and by Hartmann (1917) for *T. cruzi*.

According to Hoare (1923), development of *Trypanosoma melaphagium*, a parasite of sheep, is confined to the mid- and hind-gut of the vector, a louse-fly. Crithidia, which are predominant, are attached by their flagella to the gut wall, and division of these forms is usually unequal. Small pyriform, transitional crithidia and metacyclic stages are common. The latter are derived gradually from crithidia, or they are the result of unequal division resulting in one crithidial and one metacyclic stage. Hoare believed that leishmaniform bodies should be regarded as byproducts of any stage, and not as necessary to the life cycle. In a later paper, Hoare (1931) outlined the cycle of *T. grayi* in *Glossina*, where the blood form changes to crithidia which later divide unequally to produce large and small crithidia, including "filamentar" types. A form of division giving rise to two types of daughter cells—a crithidia and a "crithidiomorphic" trypanoform individual—was found. After numerous binary divisions of small crithidial stages, the short metacyclic flagellates were produced.

Gomes and Cruz (1927) were the first definitely to establish the existence of intracellular leishmaniform bodies of *Trypanosoma cruzi* in the gut epithelium of a triatomid bug. These bodies were identified as a phase in the life cycle necessary for infection by the bug. Shortt and Swaminath (1931) described an unusual cyst formation in the gut of *Phlebotomus babu* v. *shortti* after a meal of gecko blood infected with *T. phlebotomi*. Each trypanosome became spherical and commenced to divide, but the daughter parasites remained together surrounded by the periplast of the original parent trypanosome. Within 24 hours the primary cyst contained 40–60 aflagellate individuals. The cyst became divided into compartments. At 72 hours each of the compartments had divided into chambers, or secondary cysts about 9.5 microns in diameter, each containing a group of motile parasites. The rupture of the cyst wall liberated the parasites in the intestinal tract.

Such an elaborate form of encystment as that described above has not been reported for other species within an invertebrate host, but *Schizotrypanum* (= *Trypanosoma*) *pipistrelli* was found by Chatton and Courrier (1921) in a bat in which it formed large (up to 200 microns) reproductive cysts in various organs. Smaller cysts have occasionally been observed. Minchin (1908) found stages of encystment of *Trypanosoma grayi* in the proctodaeum of tsetse flies; while Hindle (1909) described the asexual cycle of "indifferent" forms of *T. dimorphon* as cyst formation in the horse. His illustrations of a cyst form, however, look like a non-flagellated leishman body. Such "cysts" as are mentioned above have been described by other authors as degenerate cells or merely as artifacts produced during preparation of the slides. Wood (1934) stated that "morphological and experimental data in the writer's experience do not favor

the existence of cysts of *T. cruzi* in the feces of *Triatoma protracta*."

Whitaker (1933) believed that in the insect host ingested *Trypanosoma cruzi* may be transformed to crithidiform stages by a body reorganization in which "the anterior end of the metabolic cylindrical form becomes attenuated resulting in a tadpole-shaped organism in which the nucleus has been squeezed posteriorly . . . the whole organism then elongates . . ." He also said that "the crithidial forms are more commonly derived from the ingested trypanosomal form in a less direct transformation. The cylindrical form, and much broadened trypanosomal form may lose their undulating membrane, and shorten themselves by rolling up so as to bring the anterior and posterior ends closer together . . . becoming leishmaniform." In the bug intestine the leishmaniform body "soon begins to transform into the crithidial form by outgrowth of the axoneme at the future anterior end." It is well to recall here that Dias (1934) has shown that crithidials of the insect intestinal contents are non-infective to the vertebrate host. He concurred with the belief of earlier writers that crithidial stages appear in the blood.

Whitaker pointed out that the "crithidia are undoubtedly localized in the intestine of the bug where they persist and continue to multiply as long as the host lives, serving as a continuous source for the rectal forms which metamorphose into the infective or metacyclic stage." During this metamorphosis the cytoplasm is concentrated at the posterior end of the cell so as to result in a shift of the kinetoplast to a position behind the nucleus. Another method of metacyclic formation described by Whitaker is a differential division of the crithidial form into one crithidia and one metacyclic cell. In his Plate 6, Figs. 29, 30, and 31, Whitaker figured three stages in the transformation of a blood form into a crithidia. It is important to note that these figures are practically identical with those presented by other authors as evidence for a direct development from leishmaniform bodies to metacyclic stages.

Elkeles (1940) has outlined the life cycle of *Trypanosoma cruzi* as follows: trypanoform stages (in cultures) are produced directly by unrolling of leishmaniform bodies ("leishmania of the 2nd order") which, in turn, are produced as the result of a process of schizogony. The trypanoform flagellates develop regressively into leishmaniform bodies ("lieshmania of the 1st order") which may either develop into multinuclear schizonts or may change into crithidials.

Lewis and Langridge (1947) found that in the "saliva" of *Glossina pallidipes* "post-ventricular tadpole" stages of *Trypanosoma brucei* gave rise, by unequal longitudinal division, to the long, slender crithidials of earlier observers and to short, aflagellate crithidials which, if they survived, later developed flagella. The crithidials then multiplied and produced stouter metacyclic forms which often had no free flagella. Lewis and Langridge could find little evidence of any division of metacyclic stages. They illustrated small rounded forms which they said were apparently the result of adverse conditions. These forms, however, look very much like the young developmental stages described by Elkeles and by Wood. Meyer and Oliveira (1948) reported all stages of development of *T. cruzi* in tissue cultures. These stages included retrogression forms from adult flagellates to crithidial and then to leishmaniform cells.

In material pressed out of the hind-gut of half-grown insects (*Triatoma protracta*), my coworkers and I have found metacyclic forms numbering about twice as many as all other forms. The metacyclic stage possesses a narrow undulating membrane and a very short free flagellum. The body is frequently twisted into a cork-screw shape. Both metacyclics and other stages in the bug intestine are often grouped in clusters (rosettes) with their flagella pointing outward.

A process of irregular plasmotomy was reported by Lehmann (1952) for *Trypanosoma barbari* in the leech. This process resulted in the formation of crithidia which subsequently changed into metacyclic stages by means of a posterior migration of the kinetoplast. Barrow (1953) has made a careful study of the cycle of *Trypanosoma diemyctyli* in the leech, *Batrachobdella picta*. Trypanosomes from the blood of *Triturus* first become transformed into crithidia by means of a migration of the kinetoplast to an anterior position. The crithidia divide asymmetrically, and as they divide they become progressively shorter until they assume the form of small, motile, spherical leptomonads. The latter represent the end of the regressive phase, there being no evidence of leishmaniform bodies, and they start a progressive development of gradual elongation to the crithidials again, all the while dividing. The crithidials finally become attached to the caecal wall of the leech, cease dividing, and by a posterior migration of the kinetoplast they are

transformed into metacyclic stages. After 14 days from the beginning of experimental infection all the parasites are metacyclic flagellates.

Our observations confirm, in the main, those of Elkeles. The cycle of development of *Trypanosoma cruzi* in the insect begins with a regression of ingested trypanosomes to leishmaniform bodies which multiply by binary fission. These bodies develop either directly into trypanoform (including metacyclic) stages, or into crithidials. The latter multiply by binary fission, and they may regress to form leishmaniform bodies. We occasionally find intermediate stages between "leptomonads" and crithidiform cells, but we have found no conclusive evidence that crithidials become changed into trypanoform stages. If this interpretation is true, the problem of kinetoplast migration does not exist, because crithidial stages represent mature adult forms which, if they change at all, regress to rounded bodies. Metacyclic forms are, then, immature cells which normally require the environment of mammalian blood and tissues in order to become mature.

We believe that the cycle of *Trypanosoma cruzi* in the insect is essentially the same as it is in the mammal. While Elkeles believes that trypanoform flagellates in culture develop regressively into leishmaniform bodies, we have found that it is the crithidiform flagellate that regresses into a leishmaniform body. A similar regression from crithidia to leishmania was described by Hoare (1923) for *T. melophagium* in the sheep tick. Hoare felt that leishmania "do not constitute a definite stage of development, but are rather by-products, all flagellates being capable of rounding up under adverse conditions." If this is true, "adverse" conditions appear to be a part of the "normal" environment of the life cycle.

Intracellular multiplication of leishmaniform cells in the insect host has been described for *Trypanosoma cruzi* (vide supra), but such development is obviously unnecessary for the completion of the cycle, because it cannot occur in fluid cultures without host cells, yet inoculations from our cultures into young mice are as infective as inoculations from infected insect droppings. Multiplication of leishmaniform bodies does occur, but it may take place within host cells, or in the lumen of the insect gut.

We disagree with Elkeles (see discussion of the cycle in the vertebrate host) in the latter's belief that the metacyclic form is not a stage in the progressive development from leishmaniform bodies. It is just as difficult to imagine that some special biochemical factors found only in the insect host or in artificial cultures are responsible for a regression from a trypanoform to a metacyclic stage (as envisioned by Elkeles), as it is to imagine that a direct progression from a leishmaniform to a metacyclic flagellate is due to such special biochemical factors. After all, *some* biochemical change must be responsible for diverting development toward a metacyclic cell instead of toward a trypanoform cell, unless, of course, the leishmaniform cells are genetically of 3 kinds, one of these kinds always developing into leptomoniform-crithidials, one into trypanoform parasites, and the other into metacyclics. If this hypothesis were true, each genetically distinct type would maintain some sort of individuality throughout the entire life cycle, but there is no evidence for this hypothesis. As we shall see in the discussion of the cycle in vertebrates, Wood (1953) believes that the two chief types of blood trypanosomes are derived each from a different kind of leishmaniform body, whereas Elkeles believes that the smaller leishmania ("microleishmania") is a transition form between large leishmania and trypanosomes. However, even in Wood's scheme one metacyclic flagellate could presumable give rise to all stages in the life cycle.

THE CYCLE IN THE VERTEBRATE HOST

The method of infection of the vertebrate largely depends upon the site of accumulation of the metacyclic forms in the invertebrate. If accumulation occurs in the rectum, as with *Trypanosoma lewisi* in the rat flea, and *T. cruzi* in a triatomid bug, infection of the vertebrate is brought about by fecal contamination. If, on the other hand, the metacyclic trypanosomes accumulate in the salivary glands or mouth parts of the invertebrate host, infection of the vertebrate is inoculative, as with *T. gambiense* in the tsetse fly. Most species of trypanosomes multiply actively in vertebrate blood by binary or multiple fission.

On the basis of their reproductive behavior in the vertebrate host the mammalian trypanosomes may be divided into two distinct subdivisions, which correspond to Hoare and Coutelen's (1933) system of classification (see p. 1). Hoare pointed out the following facts (Fig. 8):

1. *T. pipistrelli* multiplies in tissues of the bat in

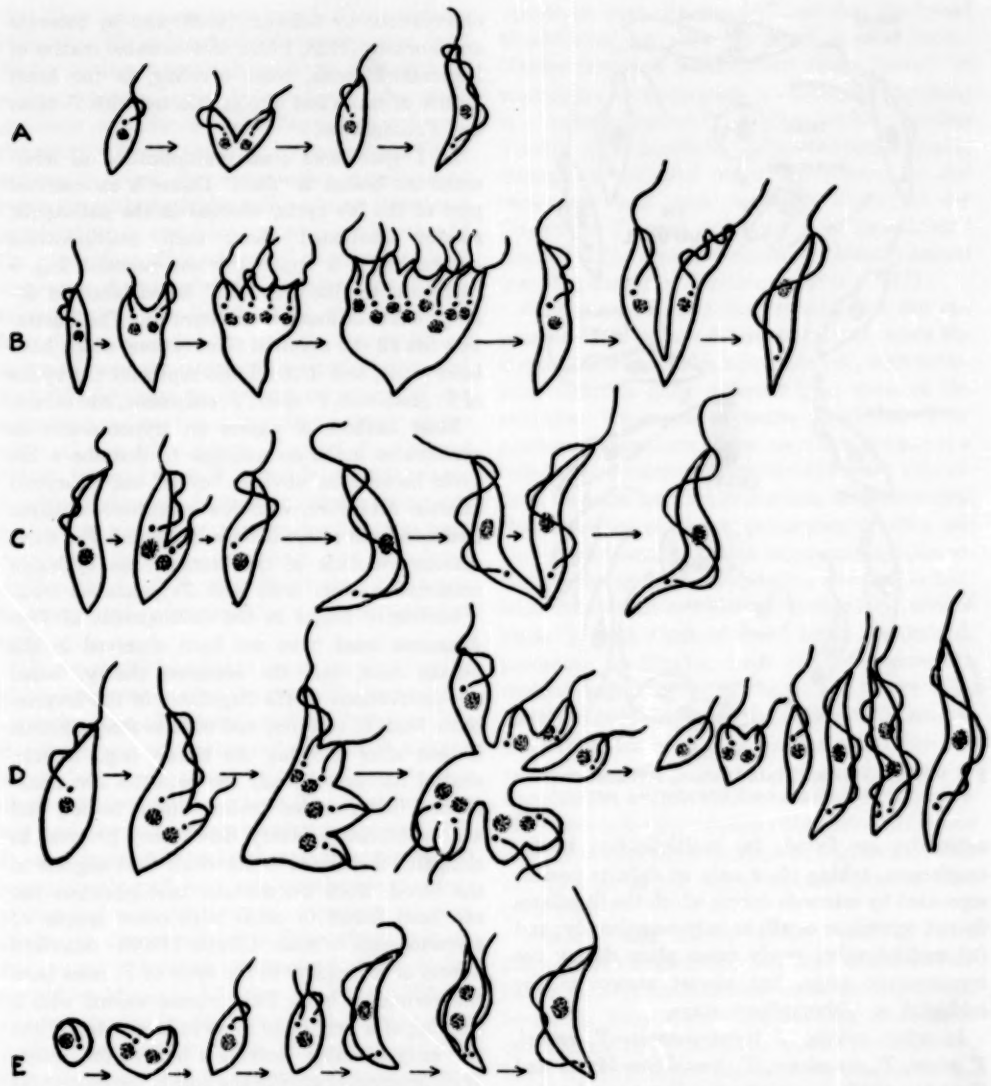


FIG. 8. A COMPARISON OF DEVELOPMENTAL STAGES OF TRYPANOSOMES IN MAMMALIAN BLOOD

A, *Trypanosoma pipistrelli* in the bat. B, *T. rabinowitschi* in rodents. C, *T. theileri* in cattle. D, *T. lewisi* in rats. E, *T. cruzi* in man. (After Hoare, 1936 and adapted from Reichenow, 1940. Courtesy of The Molteno Institute of Biology and Parasitology, and of Dr. C. A. Hoare.)

the crithidial stages instead of in the leishmanial stage. Otherwise it is similar to *T. cruzi*.

2. *T. rabinowitschi* (= *T. criceti*) multiplies in the blood. It changes to the crithidial form, then divides successively by equal, multiple fission.

3. *T. theileri* multiplies in the blood and in the tissues of cattle.

4. *T. lewisi* assumes the crithidial form in vertebrate blood, then undergoes multiple fission resulting in leishmaniform or short crithidiform stages.

5. *T. cruzi* develops as leishmanial bodies in "fixed" tissue cells.

In each of the above species the following char-

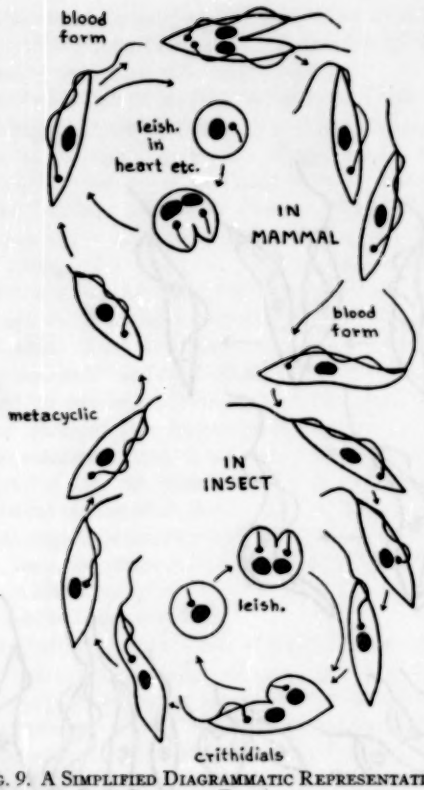


FIG. 9. A SIMPLIFIED DIAGRAMMATIC REPRESENTATION OF THE LIFE CYCLE OF *TRYPANOSMA BRUCEI*

acteristics are found: (a) multiplication is discontinuous, taking place only at definite periods separated by intervals during which the flagellates do not reproduce at all, or only occasionally; and (b) multiplication rarely takes place during the trypanosome stage, but almost always in the crithidial or leishmaniform stage.

In other groups of trypanosomes—*T. evansi*, *T. vivax*, *T. congolense*, *T. brucei* (see Hoare and Coutelen, 1933)—multiplication is not restricted to any special period, but is continuous throughout the entire course of infection. The typical method of reproduction in these groups is by equal, binary fission in the trypanosome stage; the crithidial stage never occurs during the course of development.

In 1928 Peruzzi described large accumulations of leishmaniform bodies of *Trypanosoma brucei*, *T. rhodesiense*, and *T. gambiense* in heart muscle of infected monkeys. The bodies showed definite signs of division. These findings were fully confirmed by Hoeppli and Regendanz (1930). Similar observations by Schwetz (1928) and by Schwetz and Fornara (1928, 1929) demonstrated masses of leishmanial forms, some dividing, in the heart muscle of cattle and of pigs infected with *T. vivax* and *T. congolense*.

In *Trypanosoma cruzi* multiplication of leishmaniform bodies in "fixed" tissues is an essential part of the life cycle, whereas in the pathogenic species mentioned above such multiplication occurs, but it is apparently not essential. Fig. 9 represents the life cycle of *T. brucei* based on descriptions to be found in the literature. The illustration fits all the essential observations which have been made, and it could also represent the cycles of *T. gambiense*, *T. vivax*, *T. congolense*, and others.

Most authors of papers on trypanosomes in vertebrates make no attempt to describe a life cycle because no obvious "cycle" exists beyond mitosis. Moreover, with few exceptions, a tissue leishmaniform phase is only incidental. For these reasons the bulk of the literature on cycles in mammalian hosts deals with *Trypanosoma cruzi*.

Successive stages in the development of *Trypanosoma cruzi* have not been observed in the human host, but the accepted theory, based on observations of the flagellates in the invertebrate host, in cultures, and in laboratory animals is that after invading the tissues (e.g., muscle, central nervous system) the parasites are transformed into rounded leishmaniform bodies, and after consecutive binary fission they progress to elongated flagellated forms which then migrate to the blood. Such intracellular multiplication has not been found to occur with other species of trypanosomes in man. Chagas (1909b) described a form of schizogony in the cycle of *T. cruzi* from the vertebrate lung. This process started with a bending of a long body so as to form a loop—the two ends touching—leaving a hole in the center. With progressive growth the hole in the center was obliterated, and successive divisions of the nucleus formed 8 schizonts enclosed within the original parent cell membrane. In a later paper Chagas (1911) pointed out that the multiplication of parasites in the tissues represents asexual reproduction which serves to augment the numbers of flagellates in the circulation of infected animals.

Mayer and da Rocha-Lima (1912, 1914) studied the developmental pattern of Brazilian *Trypanosoma cruzi* in mice. They believed the slender forms originated from recently arrived trypanosomes undergoing schizogony in the blood. They thought

that these forms penetrated muscle tissue, became rounded with reduced flagellar apparatus, and finally became large leishmaniform cells with or without flagella. After binary fission the leishmaniform cells unrolled, with flagellar growth over the rounded bodies, to form trypanosomes. These authors believed that progressive development beginning with the leishmaniform stage includes a crithidial stage, and later a posterior migration of the kinetoplast. This scheme of development is in contrast to the writer's belief, supported by Elkeles (vide infra) and by Wood (1953), that leishmaniform bodies can develop directly into trypanosomes without the intervention of crithidials, and that this development involves movement of the cytoplasm and nucleus rather than a simple movement of the kinetoplast. M. and P. Delanoë (1912) believed that *T. cruzi* in mouse muscle developed through leishmania, leptomonas, crithidia, and trypanosome stages, as they have been reported to do in the insect host. But, as pointed out by Wood (1953), their illustrations can easily be interpreted as representing a different kind of cycle.

Elkeles (1942) found that the stages of regression of *Trypanosoma cruzi* to the round bodies were the same in mice, *Triatoma*, and in cultures. The flagellates became shorter and more rigid, and the kinetoplast, accompanied by a large vacuole, was displaced toward the nucleus. The flagellum was lost and the undulating membrane became still. It is of interest to note that the figures of the rounded cells, each with a vacuole beside the kinetoplast and each the result of regression, are very similar to the vacuolated leishmaniform cells in the process of forming trypanoform stages as described by Muniz and Frietas (see below). Elkeles also found crithidia-like forms which should not be confused with true crithidia. He pointed out that regression may lead to leptomoniform organisms instead of to the round leishmaniform bodies.

Elkeles (1940, 1942, 1944, 1945, 1951) has emphasized the absence of crithidial stages in the vertebrate host, and on the basis of culture studies he believed that the trypanoform stages result from a direct unrolling of leishmania-like bodies in vertebrate and invertebrate hosts. He thought that Brumpt's metacyclic form is not a stage in the development of the trypanosome from the leishmaniform body, but is possibly a regression form characteristic of the invertebrate host or of artificial cultures, but never definitely confirmed in the vertebrate host. He also believed that the broad blood-forms are first produced in the insect. Elkeles described multinuclear tissue "nests" in vertebrates as undergoing a schizogony resulting in "microleishmanial" bodies which develop directly into flagellated forms without passing through a crithidial stage. Schizogony in the vertebrate host was originally described by Chagas for *T. cruzi*, and a belief in its existence resulted in the generic designation *Schizotrypanum* (see, for example, Hartmann, 1910, 1917).

Elkeles argued that the crithidia has the appearance of a mature differentiated cell, while the trypanosome resembles a juvenile cell, with structural elements quite different from those of the crithidia. The rounded forms which unroll to produce trypanoform stages are either the size of a rolled-up trypanosome considerably more voluminous than the common leishmania, with structural characteristics of the trypanosome; or they are very small forms, not much larger than a diplococcus, consisting chiefly of a nucleus and kinetoplast, with little visual cytoplasm ("elementary pairs of nuclei"). Both kinds of round forms are derived, according to Elkeles, from the schizogony-like multiple segmentation of the nuclei of large cells, mostly of crithidial origin in the insect. He has also emphasized his belief that the kinetoplast does not migrate posteriorly during the development of trypanoform stages. Elkeles concluded that leishmaniform cells may develop either into crithidia or into trypanosomes, a conclusion in agreement with the findings of the writer for the cycle in vitro (vide supra).

Romaña and Meyer (1942), working with chick tissue cultures, believed that leishmaniform bodies of *Trypanosoma cruzi* must develop within host cells. They found the usual leishmaniform to crithidiform to trypanoform type of development, but it is of interest to note that they observed some cells which possibly developed directly from the leishmaniform to the trypanoform stage. In 1944 Meyer stated that binary fission of *T. cruzi* had not previously been reported in the adult form, but he observed such divisions in parasitized fowl tissue cultures. Exceptionally large trypanosomes divided within a few minutes to form two individuals of normal size. Unfortunately, his photomicrographs do not show these divisions very clearly.

In 1946 Muniz and Freitas found that the development of *Trypanosoma cruzi* in vitro was the

same as in the vertebrate host. They believed that leishmaniform stages originate in two ways: (1) from metacyclic trypanosomes (demonstrated in guinea pig peritoneal fluid at 37° C.), a transformation that shows these stages to be orthogenetically equivalent to the leishmaniform bodies formed in tissues of vertebrate hosts; and (2) from blood forms in ordinary culture media at room temperature. Muniz and Freitas found in peritoneal fluid a direct development of leishmaniform bodies to trypanoform individuals. Slender flagellates with long nuclei were developed first. In older cultures, however, the leishmaniform stages evolved to crithidials instead of to trypanoform bodies. Muniz and Boriello (1945) observed that in fresh serum most of the crithidials of *T. cruzi* were killed, but metacyclic flagellates and leishmaniform stages were not affected. Cellular elements in the culture seemed to be essential for normal transformations. In peritoneal fluid the leishmaniform stages may evolve into trypanoform stages directly by the formation of a vacuole beside the kinetoplast and at one edge of the rounded cell. The cell membrane breaks at the vacuole and the cell straightens and elongates.

Wood (1951) has described two types of development for *Trypanosoma cruzi* in mouse muscle. The commonest process is an indirect one involving a transformation from a leishmaniform to a trypanoform stage by cell changes involving a V-shaped split between the kinetoplast area and the anterior flagellar area followed by a twisting of one or both ends of the parasite in accordance with the shallow spiral growth pattern of the flagellum over the leishmaniform sphere. Wood also found a process of direct development during which the cytosome elongates with displacement of the nucleus along the growing axis of the flagellum, the elongating cell mass tending to follow the flagellar line of growth.

Trypanosoma ariarii, described from man by Groot, Renjifo, and Uribe (1951), multiplies by binary fission in human blood. In the insect *Rhodnius prolixus* and in cultures the usual progression from leishmaniform bodies to leptomoniform to crithidiform to trypanoform stages was reported. Parasites were not found in the viscera or tissues of experimentally infected mice.

A recent detailed account of a trypanosome life history is that of Davis (1952) for *Trypanosoma zapi*, a member of the "lewisi" group from the jumping mouse, *Zapus princeps alleni*. In the rodent multiple fission of the parasite is restricted to the narrow capillaries of the heart, lungs, and other organs. Within the capillaries leishmaniform bodies develop progressively into leptomonad forms, crithidials, and finally to trypanoform stages. A rare, secondary mode of reproduction occurs in the blood, where crithidials divide by binary fission. The tissue stages of this parasite are remarkably similar in appearance to those of *T. cruzi*.

In the mouse flea, *Megabothris abantis*, *Trypanosoma zapi* completes a cyclic development similar to that described for *T. lewisi* in the rat flea, where attached and free-swimming crithidials become transformed into metacyclic trypanosomes. *T. zapi* in culture assumes the same stages as found in the flea, with the addition of rosettes.

Mrs. Davis (loc. cit.) has emphasized her belief that "the essential change in the origin of a metacyclic trypanosome from a crithidial form is the shifting of the kinetoplast to a position posterior to the nucleus." Her Fig. A, 12–21 shows a series of outline drawings which could well be interpreted as a direct development from leishmanial bodies to trypanoform stages without the crithidials, although she presents these figures as evidence of the kinetoplast migration theory. We again encounter the difficulty of interpreting a dynamic process on the basis of a series of static, stained cells. In his study of *Trypanosoma grayi* Hoare (1931) stated that displacement of the kinetoplast takes place during the process of cell division, rather than by its actual migration.

The most recent detailed account of the developmental cycle of *Trypanosoma cruzi* in a mammalian host is the excellent paper by Wood (1953), in which he used hematological criteria for differentiating the morphology of this parasite. He included a review of the literature, and his results support the hypothesis of Mayer and da Rocha-Lima (1912, 1914) and Elkeles (1944, 1945, 1951) of a regressive development from trypanosomes to leishmaniform parasites, and progressive differentiation of leishmaniform *T. cruzi* into trypanosomes, an intramuscular developmental cycle of about 8 days being indicated in mice.

According to Wood, *regressive* changes from trypanoform to leishmaniform parasites are indicated by decreased acidophilia and increased basophilia; increased volutinization and vacuolization; shifting of the nucleus from an oblong to

a spherical form with increase in volume; lengthening of the kinetoplast with increase in volume; reduction in length of the flagellum; disappearance of the undulating membrane; and change from an elongate, wavy, ribbon-like body to a crescent shape with ends curving together or broadening and shortening to produce a spherical body form. *Progressive* differentiation from leishmaniform to trypanoform parasites is indicated by decreasing basophilia and increasing acidophilia; decreased volutinization and a tendency for accumulation of the few remaining volutin granules between the nucleus and free flagellum; disappearance of vacuolization; change from a spherical to a laterally compressed, elongate, bacilliform type with decrease in volume; change from a rod-shaped kinetoplast to one of triangular form and eventually to a compressed oval shape, with decrease in volume; lengthening of the flagellum and development of an undulating membrane; and change of a spherical body form to a flattened teardrop shape with cytoplasmic splitting and untwisting to the trypanoform parasite, or simple elongation of the spherical body form with subsequent extension into the elongate, wavy, ribbon-like body form.

Wood pointed out that mice leishmaniform stages differ in size. Small forms develop into small progressive, transition forms, and eventually into short, slender, progressive trypanosomes. Large leishmaniform parasites elongate under tissue pressure, to become long, slender, progressive trypanosomes. Small, intermediate, and large trypanosomes, under the changing chemical environment of the host's blood, transform into regressive trypanosomes which may reinvade the tissues and repeat the cycle.

Wood found support for his conclusions in the illustrations of numerous papers, especially those from South America. Among such authors not previously mentioned in this paper are Manso Soto (1948), Mazza and his associates (several papers), Mazzotti (1940), Niño (1927, 1928), Nägler (1913), Rey Manitz (1941), and Vianna (1911). Although the illustrations of these authors could generally be interpreted to support Wood's scheme of life cycle, the authors themselves had usually formed other interpretations. Wood explained some of these differences in interpretation by pointing out that if we assume that the kinetoplast is stationary and the flagellar apparatus grows from it along a narrow wavy line over the cytosome—then by a process of simple extension of the parasite's body, aided by host edematous or muscular pressure or both, either elongated, fat, or slender trypanosomes could result.

There are no basic differences of opinion regarding the developmental stages of *Trypanosoma cruzi* in man. The probable course of development is as follows (see Fig. 10). Metacyclic forms from the insect host undergo a regression to leishmaniform bodies which are of various sizes. These bodies actively multiply by binary fission within tissue cells (e.g., muscle) and from them, either directly or indirectly, the trypanoform flagellates are produced and migrate to the blood. There is little division of trypanosomes in peripheral blood.

GENERAL CONCLUSIONS

It has been shown that the fibrils of the flagellum and those of the periplast are of about the same width. One might conclude that the flagellar fibrils originate from, and are continuous with, those of the periplast. The method of development of one daughter cell as a lateral projection of the parent cell is consistent with this suggestion because it would account for the relatively small number of fibrils in the flagellum. However, the flagellum begins at the blepharoplast, which presumably is situated in the cytoplasm apart from the cell membrane. If it could be shown that the blepharoplast originated as a granule in the periplast, the question of the origin of the flagellar fibrils would be answered.

The life cycle of *Trypanosoma cruzi* is essentially the same in the vertebrate host as it is in the invertebrate host. This cycle includes a regressive development from adult trypanoform stages to the leishmaniform bodies, and a direct progressive phase from leishmaniform bodies to the trypanoform flagellates without the intervention of crithidials (Fig. 10). Metacyclic stages in cultures and in insects are probably derived directly from leishmaniform bodies which, in turn, are maintained by mitotic division. The fate of crithidiform stages has not been definitely determined. Do the leptomoniform and crithidiform stages develop into metacyclics? In cultures the evidence for an affirmative answer to this question is indirect. When half of the culture forms are metacyclics and half are leptomoniform, and at the same time there are few leishmaniform bodies and few dividing metacyclics, one may infer that the latter have been produced by a metamorphosis of the leptomoniform individuals. But intermediate stages

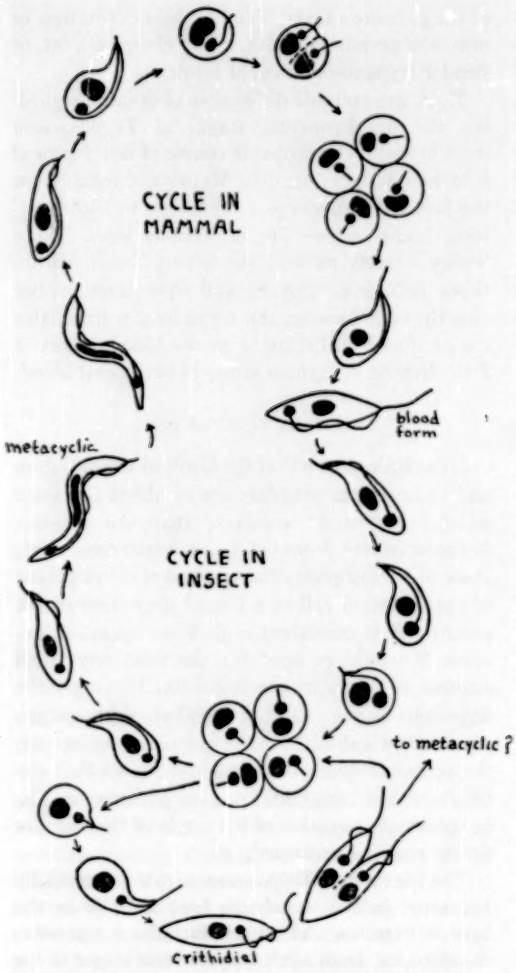


FIG. 10. A SIMPLIFIED DIAGRAMMATIC REPRESENTATION OF THE ENTIRE LIFE CYCLE OF *TRYPANOSOMA CRUZI*

between these two are generally rare or absent.

Stained preparations of leptomoniform and crithidiform stages of all species of trypanosomes frequently are found to have flagellates whose kinetoplasts are at the level of, or even a little posterior to, the nucleus. One must remember, however, that these cells are highly plastic, and that when killed and fixed the normal spatial arrangements of their contents are readily distorted.

Nevertheless, most writers have stated that metacyclics are derived from crithidials by means of a posterior migration of the kinetoplast and undulating membrane. Conclusive evidence for this migration has not been presented. We believe that emphasis should be placed on movement of the cytoplasm as a whole rather than of the kinetoplast alone. Shifts in the relative positions of the nucleus and kinetoplast normally take place during cell division. As the leishmaniform body develops, the cytoplasm grows in such a manner as to effect a change in the position of the kinetoplast with respect to that of the nucleus.

The identification of developmental stages in the invertebrate host and in cultures is more difficult than statements in the literature would indicate. The distinction between leptomonad and crithidia is frequently not marked. The crithidial form, we believe, should be considered as an older leptomoniform stage with certain developmental maturity, notably in the growth of the undulating membrane.

Under certain environmental conditions not well understood, numerous intermediate flagellates between leptomoniform and crithidiform stages are present. In our cultures the younger stages predominated, and in the triatomid bugs the older forms with undulating membranes were the most abundant. The use of both the terms "leptomonad" and "crithidia" for developmental stages of *Trypanosoma cruzi* seems unnecessary and confusing because they are often not clearly distinguishable, and because they represent closely related stages of growth of one individual. We propose, therefore, to omit the term "leptomanad" in naming stages in the development of *T. cruzi*. In its place we suggest using "transition" stage. The three clearly distinguishable stages in the life cycle in invertebrates would then be: LEISHMANIFORM (rounded, and without a free flagellum); CRITHIDIFORM (with long anterior flagellum and, when mature, a short undulating membrane); and METACYCLIC (with short anterior flagellum, if any, with a long undulating membrane, and a narrow undulating body). Metacyclic forms appear to be the only stages which are infective to the vertebrate host. Crithidials in the invertebrate host probably function to provide a constant and abundant supply of parasites.

Trypanosome cycles in the invertebrate host are more complicated than in the vertebrate host. More varieties of developmental stages have been reported in invertebrates. It may here be recalled that both Lavier and Elkeles emphasized their belief that the pathogenic trypanosomes in

mammals are juvenile forms whereas those in invertebrates (e.g., crithidials) are mature cells.

Trypanoform flagellates lose their flagella, become rounded, and are reduced in size to form leishmaniform bodies. This process may occur in both kinds of hosts. One wonders why a reduction in size is necessary. Cytoplasm must be lost to the surrounding medium. It is possible, as has been suggested in conversation with Dr. L. R. Cleveland, that this process is related to the cytoplasmic reorganization to be found in ciliates. Indeed, if one were to indulge in expansive speculation, probably there exists a number of undescribed fundamental homologies of growth and development among all the protozoa.

Discrepancies in published reports of developmental stages are often due, we believe, to a failure to consider differences in the composition and other characteristics of the medium (in vitro or in vivo) in which parasites are growing. We found, for example, that the addition of liver "l" fraction tended to favor the appearance of metacyclic forms in culture. In triatomid bugs with a recent infection metacyclic forms apparently predominate in the feces, while in older infections crithidials predominate. Insufficient attention has been given to temperature, pH, electrical charges, pressure of surrounding host fluids and cells, and especially to progressive biochemical changes in the medium, and the effect of these changes on the morphology and behavior of trypanosomes. Recent studies on the changes of the nucleoproteins during mitosis may help to answer some of these problems. We know that in some of our culture tubes the parasites are large; in others they are relatively small. We know that sometimes there are large floating masses of adherent leishmaniform bodies, and sometimes these masses do not exist. But we do not know why such differences occur. Until we understand more about the biochemistry of trypanosome growth we cannot accurately evaluate the significance of the numerous published reports on the details of developmental variations.

SUMMARY

1. The flagellum of trypanosomes consists of a bundle of fibrils, about 45 mμ in diameter, surrounded by a thin cytoplasmic sheath. The cell periplast contains parallel fibrils each of about the same diameter as those of the flagellum. The two groups of fibrils may have the same origin. Cytoplasmic inclusions are: vacuoles, granules of several types, mitochondria, Golgi bodies, and the kinetoplast-blepharoplast complex. The functions of volutin granules and the kinetoplast, both containing ribonucleic acid, and of mitochondria are little understood. The akinetoplastic condition occurs in nature and it can be produced experimentally. This condition can be interpreted either as a mutation or as cytoplasmic inheritance.

2. At the start of cell division in trypanosomes, the blepharoplast divides and one daughter granule retains the old flagellum while a new flagellum grows from the other daughter blepharoplast. A wide discrepancy in reports of chromosome numbers exists, but the most common number reported is 3. Spindle fibers and centrioles or polar caps have frequently been reported.

3. In general, the life cycles of trypanosomes in the invertebrate hosts consist of a transformation of the blood form to a crithidial flagellate which actively multiplies by binary fission. Leishmanial and other stages may or may not appear, depending on the species. The crithidiform stage often divides unequally to produce one crithidia and one trypanoform cell, which latter may be the infective metacyclic stage.

4. On the basis of reproductive behavior in the vertebrate host the mammalian trypanosomes may be divided into two distinct subdivisions to correspond to Hoare and Coutelen's system of classification. In the first subdivision (characterized by the *lewisi* group) multiplication is discontinuous, and takes place in the crithidial or leishmaniform stages. Multiple-equal and multiple-unequal divisions are common. In the second subdivision (characterized by the *brucei* group) multiplication is continuous, typically by binary fission of the trypanoform stage. Leishmaniform bodies may occur in the tissues of mammalian hosts infected with *Trypanosoma brucei*, *T. gambiense*, *T. rhodesiense*, etc., but with these species of parasites the leishmanial stage is not essential. In other species (e.g., *T. cruzi*) the multiplication of leishmaniform bodies in "fixed" tissue cells is an essential part of the cycle.

5. Trypanosomes exhibit a polymorphism which varies in its extent depending on the nature of the host fluids or tissues within which the parasites develop. A long slim form, a broad form, and one intermediate between these two are generally recognized in vertebrate hosts. Locomotion is accomplished by a pulling action of the flagellum and undulating membrane, and by undulations of

the body. A change of direction is effected initially by an abrupt alteration of the flagellar beat.

6. Continued claims for the existence of sexual forms in trypanosomes may be received with much skepticism. The life cycle of *Trypanosoma cruzi* is essentially the same in the mammalian host as it is in the insect host, with the addition in the latter of a cycle which produces large numbers of crithidial forms. In both hosts, and in artificial cultures, there is a regressive development from "adult" trypanosomes to leishmaniform bodies and á progressive development, directly or indirectly, from leishmaniform bodies to trypanoform stages, including the infective metacyclic forms in the insect. Leishmaniform bodies in the insect may also develop directly into crithidial flagellates which multiply by binary fission and which may regress to leishmaniform bodies or, possibly, may become transformed into metacyclic stages. The leishmaniform bodies in both hosts actively multiply by binary or multiple fission. There is little evidence to support the kinetoplast-migration theory, but the kinetoplast may change its relative position in the cell during mitosis when movement of the nucleus and cytosome takes place.

7. Our knowledge of progressive biochemical changes in the host tissues and fluids within which the parasites live must be expanded greatly before we can describe the variations in life cycles with complete accuracy.

ACKNOWLEDGMENT

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SPECIFICITY AND BEHAVIOR IN SYMBIOSES

By DEMOREST DAVENPORT

The University of California, Santa Barbara College

With illustrations by Campbell Grant

"And, being fed by us, you used us so
As that ungentle gull the cuckoo's bird
Useth the sparrow..." *King Henry IV, Pt. I.*

INTRODUCTION

Since earliest times naturalists have been intrigued with the intimate and so often highly specific associations between species which we speak of as symbioses. They have asked: "What factors bring symbiotic organisms together?" and "How are they maintained in partnership?" Yet until recently few efforts to answer these questions have been made. It has, of course, long been recognized that separate disciplines within a science progress historically in a remarkably parallel way. We are all familiar with the more or less orderly progression: "taxonomy-morphology-physiology-behavior" in the development of so many of the Life Sciences. The study of animal associations appears to be now in somewhat the same state as such a science as entomology was at the beginning of this century. At that time a great body of literature had appeared on the taxonomy and morphology of insects, while the study of behavior based on a knowledge of physiology was in its infancy. So far, as one might perhaps expect, our most noteworthy advances in the study of associations have been made in the investigation of truly social organisms. In our study of insect societies we have passed through the great, but in the main descriptive, work of such men as Fabre, Forel, and William Morton Wheeler, to the dramatic experimental contributions of Karl von Frisch. As a result of these observations and the continuing ones of Schneirla and others, we have today an extensive knowledge of the integrative factors, both physiological and behavioral, which knit together the "organs" and "cells" of the hymenopterous society. Likewise our understanding of the mechanisms controlling vertebrate social behavior is at present rapidly increasing as a result of the investigations of Konrad Lorenz, N. Tinbergen, and their colleagues in Europe. The same cannot be said of our understanding of symbioses; we are at the present time in the formative years of the investigation of the mechanisms of control of these partnerships. As Maurice Caullery in his classic *Parasitism and Symbiosis* (1952) has so clearly seen: "The question is really one of analyzing by precise experiments the relations of [the partners]... and of careful comparison of their behavior in an isolated state and in association."

It is the primary aim of this review to point out the number of fascinating problems that confront us in the investigation of behavior in symbioses, as well as to show that most of these problems, with the passage of time, can undoubtedly be solved by careful experimentation. As will be seen, one can often, by the use of relatively simple techniques, precisely identify in symbionts those stimuli which control adaptive behavior serving to bring the partners together or to maintain them in partnership. Throughout, we shall direct our attention to that behavior of symbionts which is directly related to their unique habit; such behavior must be absent in their free-living relatives. In what is to follow, a number of very different types of associations will fall under discussion. With no intention whatever of being all-inclusive, these have been selected primarily to illustrate how a careful analysis of the adaptive behavior of their members may further elucidate not only the

specific mechanisms but also the general evolutionary principles involved in their establishment and maintenance.

In the course of the consideration of these partnerships we shall hope that there may emerge a slightly different concept of symbiosis than that held in the past. We hope to demonstrate that an analysis of the behavior of partners in symbioses reveals these two-species associations generally to be examples of a much wider class of societal phenomena than has hitherto been appreciated, that is, of that class, typified by the insect society, which is *dependent for its existence* upon the evolution of highly specialized and precise "socially-adaptive" behavior in its component membership.

At the outset we must note that we are using the term symbiosis in the broadest sense of its creator, De Bary (1879). This meaning, at present accepted by the American Society of Parasitologists, has been most clearly stated by Allee and his colleagues (1949) as follows: "Within the loose bonds of the animal and plant community . . . there develope the remarkable cooperative pairings . . . commonly termed symbioses. Symbiosis is often defined to include only mutually beneficial relations of such partners. The concept of symbioses is here broadened in accordance with its literal meaning to include the phenomenon of commensalism, in which the benefit relation is one-sided, without injury to the host, and parasitism, in which the relation is typically detrimental to the host . . . . The term 'mutualism' in our usage corresponds exactly to the more limited concept of symbiosis that has been widely current."

These conceptual definitions need not concern us too much in the discussion to follow. We must indeed keep in mind that the economics of such intimate associations are of transcendent importance in the determination of those selective advantages which have furthered their success and brought them to their present evolutionary level, but in the present review our main interest is in specialized behavior, not in the economics of partnerships.

THE ANALYSIS OF ADAPTIVE BEHAVIOR

Let us first consider the problem of "searching behavior." How do symbionts "find" their partners? It is well known that many sorts of partnerships, particularly among those which can be termed parasitic, are effected without any active "searching behavior" on the part of either member. Of such a nature are associations in which normal host activity, such as bodily contact, accomplishes the spread of parasitic microorganisms from host to host, or in which a partner may be spread passively on the body of a contaminated insect. Once such passively transmitted symbionts reach their host, however, they may clearly demonstrate coordinated adaptive behavior under the influence of factors within the host. The migration of malaria sporozoites to the salivary glands of their anopheline hosts or of the fluke *Clonorchis* from the human duodenum to the opening of the bile duct may be examples. It goes without saying that behavior of this kind in forms so difficult of access has been uninvestigated.

Associations between some invertebrates and their algal symbionts may also be effected without active "searching behavior" in either partner, but we must be on the lookout for it. Although in most actinozoans the symbionts are passed from parent to offspring through the egg, in other invertebrates reinfection appears to be necessary. In such cases either the host must have evolved some specialized behavior which enables it to select the symbionts from the ambient plankton, or else, as in the case of the free-living flagellated stages of the algae of the flatworm *Convoluta roscoffensis*, which are attracted to the eggs of the host by a chemotaxis (Keeble and Gamble, 1907), the algae rather than their host may be the "active" agents in effecting the association. Unquestionably, further critical study is needed to determine to what extent the behavior of members of such partnerships is "symbiosis-adaptive."

In animal associations involving symbionts which make an active search for their partners, the symbionts have evolved specialized and highly specific responses to chemical and physical stimuli that clearly serve to effect and maintain the association. Such behavior lends itself readily to the most precise analysis by investigators.

In the course of such analysis it must be kept in mind that, as Laing (1937) says, "the objects sought by any animal are different at successive periods of its existence—food at one time, shelter, a mate, or a medium for oviposition in others. Which of these objects shall be sought at any particular time depends, clearly, upon the internal conditions of the animal, for example, its state of hunger or the ripeness of its germ cells. In addition, the immediate behavior of the animal

is directly affected by *external factors*." It is unquestionably true that the manner in which the behavior of symbionts may be affected by external factors will in part be determined by sequential internal changes occurring during its life. But as yet we know so little about what specific external stimuli, either from the host or other sources, elicit particular responses from symbionts that we are hardly ready to consider their behavior in the light of internal changes. We must still, in the majority of partnerships, begin at the beginning and simply determine precisely what specific external stimuli elicit particular adaptive responses, at each stage of the lives of the partners concerned. Perhaps when this is accomplished we may make some interpretation in the light of developmental changes.

Two factors in the prosecution of this sort of study which are of some value to the investigator may have escaped the notice of ecologists in general, although most experimental parasitologists are aware of their significance. Firstly, if one can keep a host alive and healthy he need not worry too much about providing its partner with a normal environment. Thus it may sometimes be easier to maintain a normal environment for certain species that live in partnership than to do so for their free-living relatives. But more important than this, the main source of stimuli affecting the behavior of the symbiont, namely its partner, *can often be more easily manipulated in space and time* than can sources of external stimuli for free-living organisms. As examples of the numerous easily manipulable partnerships we may cite arthropod ectoparasites and their hosts, inquiline mites in freshwater bivalves, commensal crabs and their bivalve hosts, commensal polynoid worms in the ambulacral grooves of starfish, nereid and polynoid worms in the snail-shells of hermit-crabs (Fig. 1), etc.

To the writer's knowledge no really significant experimental work of adaptive behavior in symbionts was undertaken prior to the First World War, but shortly thereafter, in the nineteen-twenties and thirties, there suddenly appeared a scattering of papers which indicated a beginning of interest in its analysis. As one might expect, the first experiments of this kind involved the infectious stages of trematodes. In 1924 Faust and Meleney observed that miracidia of *Bilharzia* (*Schistosoma*) *japonica*, when in the vicinity of the host snail *Katayama nesophora*, showed a powerful response to the snail, as well as to the mucus track left by it. The response to *Katayama* did not appear until the swimming miracidia came "within a few millimeters of the range of the snail." No detailed study of the specificity of this behavior was made, but it was found that no response was elicited by two common North Chinese snails, *Vivipara quadrata* and *Lymnaea plicatula*. Shortly afterwards Barlow (1925) showed that the miracidia of *Fasciolopsis buski* chose only two snails, *Segmentina nitidellus* and *Planorbis schmackeri*, if these hosts were presented among a number of other species. These are among the first experimental demonstrations of the manner in which specificity may be determined by precise behavior under host influence. Carrying their observations into the behavior of *Bilharzia* cercariae, Faust and Meleney concluded that invasion of the mammalian host occurs as a result of chance contact with the host's surface and that there was little indication of a chemotaxis to this host. What specific stimuli released the drilling behavior was not, however, investigated. Since the work of these pioneers, references to the tendency of miracidia to respond to what appear to be chemical stimuli from their hosts have occasionally appeared in the literature. Most recently Neuhaus (1953) has studied the chemical responses of the miracidia of *Fasciola*, which do not seem to be highly specific. Responses of larval trematodes to other than chemical stimuli have also been investigated. Miller and McCoy (1930) found that the positive phototaxis of "Cercaria floridensis" brings it near the water surface where it is most likely to encounter the small fish it penetrates. Among a number of experiments on the behavior of these stages are several which indicate that changes in the intensity of light serve to release swimming behavior.

However, in spite of the fact that larval trematodes appear to be particularly well suited to investigations of the manner in which adaptive behavior is controlled by external stimuli, few critical studies of this sort have been made on them (vide McCoy, 1935; Dawes, 1946).

In 1930 and 1931 J. H. Welsh of Harvard University published two papers, the significance of which has never, in the writer's opinion, been sufficiently appreciated by ecologists. These experiments, which lend themselves to such dramatic classroom demonstration that the first observation of them is unlikely to be for-

gotten, may serve as a pattern for subsequent analysis of the behavior of symbionts. Welsh demonstrated conclusively that an adaptive pattern of behavior exists in the mites that inhabit the mantle cavity and gills of freshwater mussels. Working with *Unionicola ypsilophorus* commensal in *Anodonta cataracta*, he found that when washed free of a factor from the host the mites gave a positive response to light and that adding host-factor to an aquarium containing positively phototactic mites caused an immediate reversal of this taxis to negativity. He found, incidentally, that this taxis-reversing factor is relatively stable and that it resists boiling and putrefaction. As a result he proposed that it might be a decomposition product of mucus or some other protein from the gills. In addition, Welsh found that in darkness mites tend to collect near pieces of mussel, thus apparently indicating a positive chemotaxis to mussel substance. Whether this latter factor is the same as the phototaxis-reversing factor was not determined. In his 1931 experiments, the specificity of factors governing the behavior of symbionts was again demonstrated by Welsh. He showed conclusively that the reversal of phototaxis in each of three species of mites commensal with three species of mussels could be accomplished by a factor from its host only. This experimental demonstration of the manner in which host colonization may be accomplished by *changes* in behavior under a specific host influence marks a significant advance in our study of symbioses and in our effort to understand the evolution of such associations.

We have little detailed information about the behavior of the early stages of these inquiline mites studied by Welsh. Obviously they must move from host to host; otherwise their spread would never be accomplished. One may wonder whether during larval life the mites exhibit that positive response to light which enables them to wander more widely. If so, one may suppose that subsequently internal changes take place which "trigger" the reversal of response under the influence of the host-factor. This mechanism, plus a positive chemotaxis appearing at the same time either to the same or to another host-factor, would insure colonization of hosts when the larvae are in proximity to a mussel bed. It is clear that even after twenty years much remains to be investigated in this interesting partnership.

Welsh said: "The rapid reversal ... when stimulated by extract ... is presumably a central nervous phenomenon, and might be called a 'conditioned reflex.' Doubtless many parasitic animals become conditioned to stimuli from the host and show adaptive reactions quite different from their primitive responses." It may have been unwise to use the classical term "conditioned reflex" for this behavior. It appears from Welsh's experiments, in which one eye of a mite was blinded and a reversal of circus-movements occurred under host influence, that a nervous mechanism as simple as we believe reflexes to be was involved. But a conditioned reflex involves repetitive subjection to one external stimulus so that specific behavior may be released by it in place of another stimulus. We have here little evidence that repetitive or continued subjection to a host-factor is necessary for the factor to accomplish a reversal of the response to light. Indeed, as we shall shortly see, although true conditioning has been shown to be of importance in host-selection, it appears entirely possible that this ability to change behavior suddenly at the first experience of external stimuli from the host may be firmly fixed in the hereditary constitution of symbionts.

For an appreciation of the importance of conditioning in host-selection and its possible effect on the origin of new partnerships, one may turn to an animal relationship which by our previous definition can hardly be considered symbiosis. However, the related phenomenon of parasitoidy in insects has been intensively investigated because of its obvious economic importance. Insect parasitoids kill their hosts and therefore are perhaps best considered internal predators. Yet the laws that govern their behavior are just as applicable to the members of more cooperative associations known as symbioses. Among arthropods and vertebrates true predators with specialized food habits may locate their prey by highly precise behavior involving, at least in part, olfactory recognition of the prey. That this precise predatory recognition is of importance among lower groups has been demonstrated in a few cases (Stehouwer, 1952; Braams and Geelen, 1953). Although it had been known that olfactory recognition of the host was of great importance in host location by insect parasitoids, it remained for Laing (1937) of Cambridge University to point out a phenomenon of much wider application and importance. By means of a choice-apparatus she demonstrated that parasitoids may be attracted by olfactory

means *to the environment* in which hosts are found. The chalcid *Alysia manducator* is attracted to a place where its host blow-fly larvae are found as a result of a powerful chemotaxis to some factor or factors in decomposing meat. The act of consummation in this particular relationship, that of egg-laying in the host, is accomplished by still another stimulus to the parasitoid, that of the movements of the host larvae in the decomposing meat. That in some cases the act of egg-laying may release a chain of specialized behavior which increases the chances of finding more hosts was demonstrated in *Trichogramma*.

Laing has here stated principles which are highly applicable to all studies of symbionts' behavior. She says: "The conclusion to be drawn ... is that some parasites do first seek out a particular environment, in which they afterwards proceed to seek their hosts. The analysis of the process by which the parasite finds its host into two parts—the finding of the environment and the finding of the host in that environment—is, therefore, not merely a convenient theoretical division, but corresponds to an actual difference in the behavior of the parasite." And further: "Not only, then, do some parasites find environments first and hosts later, they may often use quite different senses for the perception of the two and make quite different movements to reach them. What those senses and movements are, however, will differ greatly with different parasites, and *must be especially determined in each particular case*" [italics added].

Concurrent investigations in England brought to light the theoretical importance of the continued subjection of the parasitoid to chemical influences from the host. Thorpe and Jones (1937) discovered that if the eggs of the parasitic wasp *Nemeritis*, normally a parasite of the wax-moth *Ephestia*, were artificially introduced into the abnormal host wax-moth *Meliphora* (to which *Nemeritis* normally gave no response), the resulting adults would demonstrate a strong response in an olfactometer to this "new host," when they were faced with a choice between *Meliphora* and a blank. However, these workers were never able to demonstrate in such conditioned wasps an egg-laying preference for the "new" host over the old. Later, Thorpe (1939) demonstrated that one could elicit a strong olfactory response from adult *Drosophila* to a number of chemical substances which never occur in their usual environment, provided they had been raised in media containing these agents. The importance of these physiological studies to our understanding of the role of chemical factors in symbioses and host-selection cannot be overestimated. However, it must also be kept in mind that even among symbionts of a relatively low level of organization there is always the possibility that the young may be conditioned to a number of stimuli other than chemical ones from the host, in much the same way as a young cuckoo, according to the studies of Southern (in Huxley et al., 1954), appears to be conditioned while in the host's nest to a number of physical characteristics of the host and its environment.

From the above studies it appears that once a behavior pattern is established which serves to bring host and symbiont together, the original stimulus which elicited it may be replaced by a different one. Here we have, without recourse to Lamarck, a mechanism for the evolution of a new host habit, and as Cushing (1941) has suggested, such conditioning, acting as a mechanism of isolation, may be thought of "as a physiological factor acting upon population mechanics that does not depend upon genetic changes for changes in its specificity of action." But, of course, as Dethier (1954) says in his review of feeding preferences in insects: "The crucial problem is whether a phenomenon like olfactory conditioning can bring about sympatric splitting of a single population into two non-breeding populations." He continues: "It is clear that in the absence of effective isolating mechanisms there would be free hybridization between individuals with different ... preferences so that the preferences fostered by olfactory conditioning could never become sorted out genetically.... Thus, in evaluating the significance of olfactory conditioning as an effective factor in establishing populations with new ... preferences, a question of fundamental importance arises, i.e. whether olfactory conditioning by itself can lead to any kind of isolation ... or whether the isolation must be interjected from another quarter."

It is indeed difficult to see how olfactory conditioning could alone effect isolation, but what if we could demonstrate that in certain symbioses the presence of a specific host-factor determines host-selection and at the same time effectively prevents the adult symbiont from leaving its host? Here, the factor involved in host-selection certainly is a factor tending to isolate individuals. Actually, in

certain cases of commensalism or ectoparasitism in which the adult symbiont is continuously in contact with its host, olfactory conditioning could very well initiate the genetic isolation of populations that is necessary. Let us suppose that during a brief free developmental stage a symbiont happened to encounter some "potentially new" host in a somewhat different niche than that of its old host. If this symbiont "fell under the influence of" and was prevented from leaving this new host as a result of the production by the new host of a factor perhaps related to but not quite similar to that of its old host, then an *effective* conditioning to the new host factor bringing about a change in host-preference, aided perhaps by a shortening or loss of the free stage, might well allow subsequent generations to become genetically isolated on their new host. From then on the course of evolution of the symbiont would be controlled by that of its new environment, the new host.

Unquestionably, the above studies by Thorpe and others cast considerable light on the mechanisms whereby new host habits may be established in certain sorts of associations, particularly among groups of taxonomically closely related symbionts, members of which have colonized distantly related hosts. But as we shall shortly see, an additional phenomenon (Davenport, 1953b) may make it possible at least in some types of associations to discard the necessity of conditioning as a factor of importance in the initiation of a new host habit.

In 1948 there appeared another important British paper, which, although it did not contribute greatly to our theoretical picture of the evolution of host specificity, is such a model of precise investigation that it deserves to be mentioned here. Lees carefully analyzed the responses of the sheep-tick *Ixodes ricinus* L. to light, contact, gravity, temperature-change, moisture, vibration, and the chemistry of the host integument. He demonstrated conclusively that "all the sensory perceptions are of value in promoting survival or host-finding," their function in toto being to bring the tick to its host mammal. Lees' methods in determining the total effect of a number of precisely analyzed sensory perceptions and responses could well be applied to a great many symbiotic associations.

Of recent years the writer has extended researches of this sort to marine associations, because of the ready availability of numerous partnerships in the sea and the ease with which their experimental environment can be kept constant. These investigations (Davenport, 1950, 1953a, b; Davenport and Hickok, 1951) have largely been studies in the specificity of chemical recognition of hosts by commensal polynoid annelids. The technique (Davenport, 1950) used in these studies fundamentally differed little from those used by Thorpe in his studies of insect parasitoid behavior cited above. It may, however, serve as an example of one way in which chemical recognition in marine animals may be investigated. A choice-apparatus or olfactometer was employed. Commensal worms were introduced into a Y-tube and were presented with a choice between streams from two aquaria. Material to be tested could be placed in either aquarium at random; similarly, connections with the aquaria were so arranged that streams to be tested could be introduced into either arm of the Y at random, thus making it possible for any consistent behavior resulting from uncontrolled inequalities in pressure or light to appear in the data from a large number of "runs." Such apparatus lends itself well to the investigation of host specificity in active forms which readily respond to streams of water carrying attractants.

Without exception, all polynoids so far investigated have demonstrated strong positive responses to chemical stimulation by their hosts. In some forms it has been possible to demonstrate the response with the above choice-apparatus, whereas in others very close proximity or even direct contact with the host was necessary for a typical recognition-response to be elicited. Thus, chemical attraction and recognition appears to be the usual mechanism binding partners together in cases of the scale-worms *Arctonoë fragilis* commensal with the starfish *Evasterias troschelii; A. pulchra* with the sea-cucumber *Stichopus californicus; Acholoë astericola* with the starfish *Astropecten irregularis; Hesperonoë adventor* with the echiuroid worm *Urechis caupo; Halosydna brevisetosa* with the terebellid worm *Neoamphitrite robusta; Polynoë scolopendrina* with the terebellid *Polymnia nebulosa; Lepidasthenia argus* with the terebellid *Amphitrite edwardsi; Harmothoë spinifera* with the terebellid *Amphitrite gracilis;* one population of *Harmothoë lunulata* with the brittle-star *Acrocnida brachiata*, one with the sea-cu-

cumber *Leptosynapta inhaerens*, and one with the terebellid *Amphitrite johnstoni*.

In most of the polynoid-terebellid partnerships the response of commensal to host (with certain highly interesting exceptions to be discussed) was highly specific, in spite of frequent close taxonomic affinity among hosts. On the other hand, in the one polynoid-echinoderm partnership to be investigated in this way, that of *Acholoë* and *Astropecten*, the commensal gave relatively marked responses to a number of stars other than the host. Some of these response-eliciting starfish were closely related to the host and some were not. All were taken in the same general environment (the English Channel) but not in the same localized one (the Eddystone Grounds on coarse sand) as the host. It would seem that in this case the commensal has developed a response to a relatively widely distributed substance or pattern of substances and that other ecological factors prevent its colonizing other forms to which it demonstrates a response in the laboratory.

To date, efforts made to extract attractants from several of these hosts have not been successful. It would appear that the factors are either masked by other substances in the course of preparation or are so unstable that in the effort to extract them they are changed or destroyed. A number of sources of evidence (Davenport and Hickok, 1951; Davenport, 1953a) appear to make the latter the most probable.

What may have been from the theoretical point of view the most important observation in these studies appeared as a result of routine investigation of the specificity of response to hosts. In certain commensal polynoids a population taken from one host may often show as strong a response to an alternative host as to its own. This occurs in spite of the fact that the alternative host may be only very distantly related to its own host; indeed, the response to the distantly related alternative host, perhaps of a different family, order, or class than that of its own host, may be far stronger than any response shown to other members of the host genus. As an example, a *Harmothoë*, collected from and showing a strong response to the host terebellid worm *Amphitrite gracilis*, shows an equally strong response to an alternative host, the eunicid *Lysidice ninetta*. To other members of the family Terebellidae to which its host belongs it gives either no response or a very weak one. If we believe that we have adequately demonstrated these responses to be a fairly simple matter of chemical recognition, then we must conclude either that the commensal responds to a single attractant produced by both of the unrelated hosts, or to two different, yet specific, attractants. It seems unlikely that a single commensal species would demonstrate a precise inherited response to each of two different attractants. Furthermore, animals produce many sorts of metabolites, and it is certainly probable that unrelated species may produce similar, although perhaps rather specialized ones; hence it would seem that the former of the above two possibilities is the more likely. We must remember that in such associations as the annelid-annelid symbioses, the commensals could not be responding to generally distributed substances, since the specificity studies have shown that each commensal generally is attracted to a substance or pattern of substances elaborated by its own host alone. A sudden break-down of the response specificity across taxonomic barriers probably indicates similarity in attractants, particularly in view of the fact that the two unrelated releasers of the behavior actually *may be* hosts of the commensal concerned.

Here, then, we may propose an even simpler mechanism than that in which the origin of a new host habit depends initially upon rapid olfactory conditioning to a different host-factor. Conditioning may not be *immediately* necessary in some cases where there may have been a chance production by two animals of a similar metabolite, to which, in one of the two, a symbiont has become adapted. Ecological factors being favorable, the symbiont may simply proceed to colonize the other animal. Having done so, its evolution will, as previously stated, be controlled by changes in its new environment, that is by the course of evolution of its new host. It is conceivable that it may then diverge rapidly from its ancestral condition, structurally, physiologically, and in its response behavior to the changing attractants of its two hosts. It seems impossible, as an example, that the three so morphologically similar species of *Arctonoë* of the Pacific Coast, which colonize certain asteroids, holothuria, gastropods, amphineura, and terebellids, and show precise response specificity, did not descend from an ancestor that inhabited one of these groups alone. Since all three species now colonize some asteroids, one might guess that their first ancestral host was a starfish. But whether in this group the original

colonization of unrelated ancestral hosts depended upon the production at that time of similar attractants by these hosts will never be known.

To lend support to the above hypothesis it would be nice to discover some situations in which *two* obviously related but morphologically distinct species, commensal with hosts which are unrelated, *did* each show a response to the other's host but not to its close relatives. Under these circumstances we would have evidence that although two genetic stocks had structurally diverged, their response behavior to an attractant still produced in common by both hosts had not, and the populations had only been prevented from mixing by dissimilar ecological requirements resulting from other divergences. It is clear from the above that continued critical studies of response specificity should result in data which will cast considerable light on the path of evolution of such associations.

But what of other studies for the future? Certainly it will be agreed that the numerous and well-known partnerships in the sea should lend themselves well to investigation because of their frequent ready availability in large numbers and because of the ease with which they can be maintained and handled. The matter of determining the role of chemical attractants in partnerships involving other than annelid commensals remains pressing. Johnson (1952) has demonstrated by the use of a Y-tube choice-apparatus that water from an aquarium containing host sand-dollars (*Mellita*) has a strong attraction for the commensal pinnotherid crab, *Dissodactylus*. This is the first time that such a chemotaxis has been demonstrated in pinnotherids, though one has long suspected as a result of their habits that such a response could be shown. No investigation of the specificity of response was made by Johnson. He was unable to demonstrate the response in two other pea-crabs commensal with the polychaete *Chaetopterus* or in the oyster crab commensal with *Ostraea*. Whether in these last three any recognition response could be elicited by closer contact with the host was not demonstrated. There are numberless associations involving pea-crabs commensal within tubes of annelids, in the mantle cavity of molluscs, in the cloaca of sea-cucumbers, etc., that remain to be investigated.

Perhaps the question of maximum interest in the analysis of the behavior of marine symbionts is: "How do those with relatively long planktonic lives reach their hosts?" Up to the present time, in spite of the great number of marine commensal associations, the mechansim controlling host-colonization is not clearly understood in a single partnership in which a free-living larval stage must reach its host. As is well known, the study of settlement and metamorphosis in marine forms with free larvae is often faced with technical problems of particular difficulty. So far, no annelid commensals have been carried through to settlement and metamorphosis. At Plymouth (Davenport, 1954) the commensal polynoid *Acholoë* was carried to the late trochophore stage (10th day), but efforts to carry it further than this failed. It is of some interest that this form, which inhabits starfish at medium depths in the English Channel, has a relatively long planktonic life, when one might have suspected some method of telescoping the free larval life such as brooding, in order to insure host-colonization. Immediately, the problem of host-finding becomes paramount. However, if we recall the principle of Laing that parasites may be attracted to the environment in which their hosts are found, the manner of investigating this sort of problem may become clearer. Prior to the work of Laing, ecologists working with free-living benthal organisms suspected that the substrate had an important influence on the settlement of larvae. Most outstanding among investigations establishing this effect have been those of Douglas Wilson (1937, 1948, 1952) and of Knight-Jones (1953). These workers have shown that the settling larvae of organisms of special habit are sensitive to minute differences in their environment and that they may actually sample the substrate before settling, being either attracted or repelled by minute physical as well as chemical differences in it. As early as 1921, Mortensen noticed that metamorphosis may not always take place at a fixed stage in development and that the presence of certain factors in the environment will stimulate larvae to metamorphosis. It is somewhat surprising that in the space of thirty years statements to the effect that the settlement of marine planktonic larvae is random have not yet disappeared from many general ecological publications.

Be that as it may, it is obvious that in many marine symbionts we are likely to find that the physical or chemical nature of surfaces determines metamorphosis. One study indicating this has already been made. Bourdillon (1950), in discussing the relationship of the commensal mussel

Modiolaria and its host ascidian has said: "Le déterminisme de la fixation des *Modiolaria* doit donc être recherché dans al tunique elle-même.... Il semble donc que ce soient les glucides à grosse molécule (c'est-à-dire la tunicine elle-même) qui conditionnent la fixation préférentielle. Les expériences, que j'ai entreprises, de fixation de *Modiolaria* sur des nitrates de cellulose ont apporté quelqu'appui à cette hypothèse."

It is very likely, however, that in some cases the point of first settlement will not be the host itself. On echinoderm hosts of polynoids the minute recently settled larvae of commensals have apparently never been found. As a principle, might it not be wise in the course of attempts to rear such forms to try to induce settlement on the substrate where the hosts are found? Perhaps, as an example, later *Acholoë* larvae could be induced to metamorphose on the coarse sand of the Eddystone Grounds. Theoretically, in so far as evolution is concerned, this would "make sense." It is probable that many symbioses had their origin in the coming together of two free-living forms that lived closely together in the same environment. A pattern of behavior long established in the heredity of such a commensal would insure that it would settle on its ancestral environment, which may be *where the host already is*. In that case, searching behavior aided by sensitivity to a specific host factor would enable the commensal to find its host without too much difficulty. During such a process there would undoubtedly be wastage and mortality, but it would be nowhere near as high as if meeting were only random.

Another crucial question immediately becomes apparent. Is this highly specific recognition behavior, undoubtedly released by various sign-stimuli from hosts, genetically determined or individually conditioned? It seems most difficult to believe that it is not the former, though this remains to be proved. It ought to be possible to demonstrate whether or not this highly precise recognition of the host is genetically determined. On the Pacific Coast there is a very common commensal hesionid worm, *Podarke pugettensis*, which lives in the ambulacral grooves of the starfish *Patiria*. The hesionid can also be obtained in great numbers in the free-living state. Does the behavior of the two populations relative to *Patiria* differ? Can both populations be raised to metamorphosis and settlement? What factors control settlement in each case? Can the populations be crossed? *If so, what sort of behavior would the* F_1 *show?* If we had concise answers to all the above questions concerning this familiar partnership, we would know more about the principles governing the evolution of marine symbioses in general.

There remains the basic investigation of the control of adaptive behavior in the numerous fascinating partnerships in the sea that have aroused the interest of naturalists since earliest times. Examples wonderfully suited to critical study are such symbioses as those between hermit-crabs and anemones (Faurot, 1910; Cowles, 1919); between hermits and commensal nereid worms (Fig. 1) (Thorson in Caullery, 1950; Brightwell, 1951); between crabs of the genus *Melia* and the anemones they brandish in their claws (Duerden, 1905); between the fish *Carapus* (*Fierasfer*) and its host sea-cucumber (Fig. 2) (Arnold, 1953); and between pomacentrid fishes of the genera *Premnas* and *Amphiprion* and their anemone hosts (Vervey, 1930; Gudger, 1947; Gohar, 1948). A fascinating partnership that appears to be totally uninvestigated is that in the western Pacific of the wonderfully modified striped fishes of the genus *Aeoliscus*, who stand on their heads over the long spines of their host sea-urchin (Fig. 3). What stimuli elicit this curious behavior? The above citations indicate that many of these associations have been studied and described; in some, a few simple experiments on specificity have

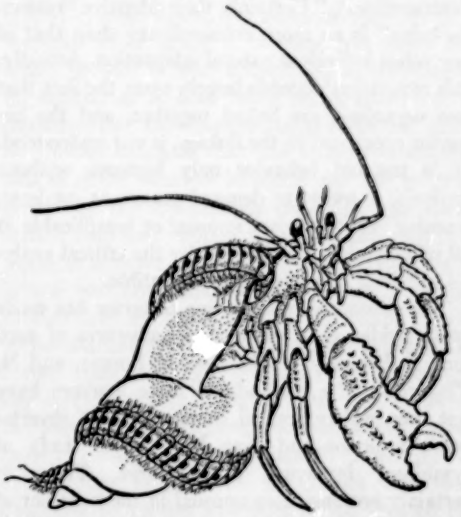

FIG. 1. *NEREIS FUCATA* ENTERING A GLASS SHELL HOUSING ITS HOST *EUPAGURUS BERNHARDUS*

FIG. 2. THE PARASITIC FISH *CARAPUS ACUS* (FIERASFER), TWISTING ITS WAY INTO THE CLOACA OF THE HOST SEA-CUCUMBER, *HOLOTHURIA TUBULOSA*

(After Arnold, 1953)

been conducted. But in every case without exception the behavior concerned is in need of precise experimental analysis by modern techniques. In each case we must identify stimuli eliciting special behavior and determine precisely the manner in which the partners are first brought together. As one may observe in many ecology textbooks, these associations have acquired a reputation of being "unique," "unusual," or "extraordinary." Certainly their adaptive "reason-for-being" is no more extraordinary than that of any other individual natural adaptation. Actually, this reputation depends largely upon the fact that two organisms are linked together, and the behavior concerned in the linkage is not understood. It is unusual behavior only because, without analysis, it seems to demand reason or, at least, learning. That it is not unusual or inexplicable at all will certainly be disclosed by the critical analysis to which it is so clearly susceptible.

The science of comparative behavior has made great strides as a result of the advances of such men as Kingsley Noble, Konrad Lorenz, and N. Tinbergen. The methods of these workers have not been widely applied to the study of invertebrate behavior and even less to the study of symbioses involving invertebrates. There is certainly nothing more unusual in the behavior of a hermit crab in transferring an anemone from its old to its new shell than there is, for instance, in the behavior of mating sticklebacks. There are, of course, numerous studies in which complicated chains of behavior have been described, but the studies whereby Tinbergen and his colleagues (Pelkwijk and Tinbergen, 1937; Tinbergen, 1951, 1953), using models and artifacts, have broken down into its component parts the wonderful courtship sequence in *Gasterosteus* are now among the best known of these studies in which a critical experimental approach has been used. In these experiments individual animals were manipulated in space and time, and models were used in a successful effort to determine what behavior, in part under internal drive, was released by what external stimuli. As a result, the whole complicated chain of behavior, from the time of the appearance of the male until fertilization is accomplished, can now be better understood. Each behavioral step, often triggered by a single sign-stimulus, can be seen to be the consequence of the immediately preceding one.

These studies dealt with a common phenomenon of behavior, namely that of mating, exhibited by two members of the same free-living species. That the difference between a transitorily intimate association of two members of the same species

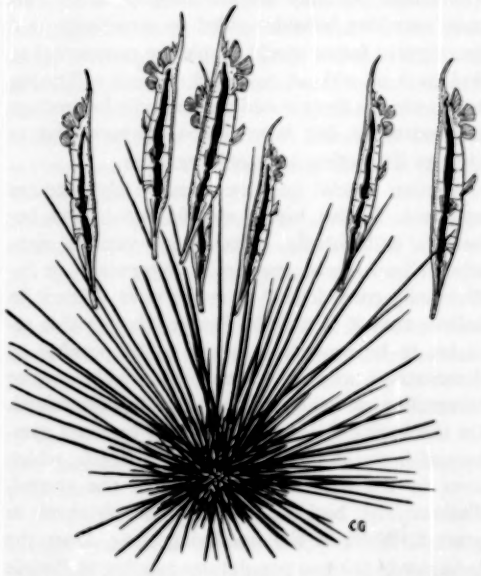

FIG. 3. A GROUP OF *AEOLISCUS STRIGATUS* IN ASSOCIATION WITH THE LONG-SPINED SEA-URCHIN

(Modified from a photograph by René Catala, *Life* magazine).

and a more permanent one of two different species is, from the point of view of behavior, merely one of degree is illustrated by a number of well-known cases where specialized mating behavior verges on parasitism. Though it may be possible, it will probably be some time before we determine experimentally what stimuli accomplish the permanent union of the males and females of the abyssal fishes of such genera as *Ceratias* and *Edriolynchus*, in which the males are firmly attached to, though not certainly physiologically dependent upon, the females. It should perhaps be more feasible to determine what stimuli accomplish the truly parasitic union between the sexes of the echiuroid *Bonellia*, in which the male inhabits the nephridium of the female. An additional factor of some interest must be important in the case of *Bonellia*, for it is known that if the larva of this worm settles on a female, it will become a male, whereas if it remains free it becomes a female. Does colonization of the female by an undetermined larva happen by chance? What is the nature of the stimulus from the female which is responsible for sex determination in this undetermined larva, now fated to become a male?

A fascinating and rather similar association between the sexes may be observed in the case of the isopod crustacean *Athelges tenuicaudus*, parasitic on the hermit crab *Anapagurus*. In a personal communication, Gunnar Thorson states that about five per cent of the *Anapagurus* taken in the Kattegat have parasitic *Athelges* females attached to them and that these *Athelges* females without exception have small male *Athelges* clinging to them. Male *Athelges* are never found alone on the hermit crabs. Here perhaps one could determine by experiment which of two possibilities is true. The sex of *Athelges* may be phenotypically determined. In this case one would have to conclude that a stimulus from *Anapagurus* causes undetermined larvae to approach it. An undetermined larva, attracted by a factor to an unparasitized *Anapagurus*, would become a female, while one attracted to an already parasitized *Anapagurus* would, under the influence of the female parasite already present, become attached to it and become a male. Here two separately acting attractants might be identified. On the other hand, it is possible that sex in *Athelges* is genetically determined. In this case one would have to conclude that only female larvae are attracted to the host hermit crab, while the males are attracted to the females by another factor. At any rate, analysis of the behavior of larval *Athelges* and precise identification of the stimuli involved in their settlement would be of great interest.

Probably more can be accomplished in the immediate future if we attempt to analyze the behavior of a number of more readily accessible and easily handled partnerships. The association between hermit crabs and anemones cited above is well known and available in large numbers to many students, particularly in Europe. The briefest of preliminary experiments were conducted by the writer in 1953 at Plymouth, where the hermit *Eupagurus bernhardus* and its anemone *Calliactis parasitica* can be had in great numbers. By use of a simple choice-apparatus it was observed that adult *Calliactis* showed no ability to "find" shells inhabited by *Eupagurus* and that for the association to be effected between these two animals, immediate propinquity of the partners was apparently necessary. Whether actual contact of the anemone with the shell or the help of the crab was necessary was not determined.

Cowles (1919) described in some detail the habits of the hermit crabs, after changing their shells, of transferring the anemones from the old to the new abode. Here is a complicated chain of behavior which could unquestionably be broken down into its component parts. In particular, what are the special stimuli which the anemone receives from the crab which cause it to come free easily and which prevent it from contracting or discharging its acontia as it does when manipulated by an experimenter? One interesting observation made by Cowles indicates that the transfer is another case of chain behavior in which each act is "triggered" by the immediately preceding one. Once, after a crab had vacated its shell bearing an anemone for another without one, Cowles moved both into a new aquarium for observation. Although Cowles does not make the point, it would appear to be impossible to do this without causing the hermit crab to retract within its new abode. At any rate, after this move, no effort was made by the hermit crab to change the anemone. Cowles said: "... further observations ... led me to believe that removal of the hermit from one aquarium to another just after it had vacated the anemone-covered shell disturbed the hermit so much that the usually instinctive behavior in

which the anemones are transferred to the new habitation was inhibited." In fact, by moving the partners Cowles broke the chain of behavior and prevented one stimulus from having its usual effect. This stimulus remains to be identified. It is probably involved in the act of transfer of the hermit crab's body to the new shell and serves to "trigger" the act of removing the anemone from the old shell. That these acts are fixed, instinctive, and occur in a definite pattern is obvious, but these interesting observations of Cowles should be repeated and subjected to new techniques of analysis.

Whatever the stimuli may be which regulate this hermit crab–anemone association, some of them certainly may turn out to be what without too broad an interpretation we may identify as social releasers. Tinbergen (1948) in his paper on methods has said: "Lorenz ... put forward the theory ... that in animals intraspecific social relations are dependent to a large extent on stimuli sent out by one individual (the 'actor') releasing mechanisms in another individual (the 'reactor'). As a result of evolutionary adaptation, many species have developed special structures or movements that serve to send out stimuli especially adapted to act on innate releasing mechanisms of the same species. It is these special structures, the exclusive function of which is to send out sign stimuli releasing social responses, that are called releasers (Auslöser) by Lorenz." We can see, then, that Lorenz's original concept was limited to *intra*-specific associations. Yet Baerends (1950) has established its extension to *inter*-specific ones, and Tinbergen (in Huxley, Hardy, and Ford, 1954) says, in speaking of the releasers involved in display: "Many inter-specific displays are symbiotic, they serve both species involved." He states that super-organismal entities (symbioses, societies) are as dependent upon releasers for their coordination and maintenance as are organs in the individual upon the correct functioning of hormones and the nervous system: "Just as the functioning of hormones and the nervous system implies not only the sending out of signals but also a specific responsiveness in the reacting organ, so the releaser system involves a specific responsiveness to particular releasers in the reacting individual as well as a specific tendency to send out the signals in the initiator. *The releaser system ties individuals into units of a super-individual order* [italics added] and renders these higher units subject to natural selection." To these ethologists the releaser system assumes a paramount role in societal evolution.

The discussion of Baerends (1950) of the role of releasers in symbioses is worthy of quotation in some detail. He says:

"While in the predator-prey and parasite-host relation a development towards each other of a releasing mechanism and the organs sending out the releasing stimuli is impossible if natural selection is the ruling principle, such a converging development is possible as soon as the activity or motivation released is of biological value not merely to the reactor, but also to the actor, the bearer of the releasing organs.

"That does not mean that in the cases of symbiosis we always find special organs in the actor that only have the function to send out sign stimuli.

"The fresh-water mussel *Anodonta*, for instance, that discharges its larvae over the bitterling, *Rhodeus amarus*, in order that they can attach to its head parts when this fish approaches the mussel to place its eggs in its expiration chamber, does not show a special development of releasing organs."

In a personal communication Dr. Baerends says that unpublished research in his laboratory has indicated no specific stimulus from *Anodonta* and that "if a chemical stimulus plays a role it cannot be very specific, as the bitterlings react in the same way to different ... genera of mussels."

However, as Baerends says, there are numerous symbioses, such as those between flowering plants and their hymenopterous pollinators, in which releasers are most definitely present and may be precisely identified. Among these he selects the highly interesting phenomenon of pseudocopulation:

"... the flowers of some orchid genera are parasitic on the releasing mechanism of some Hymenoptera which they attract without presenting them a food source ... every orchid species is here bound to only one or two insect species. In Europe and North Africa several students ... have found combinations of *Ophrys muscifera* with the Sphegid wasp *Gorytes mystaceus*, of *Ophrys speculum* with the Scoliid wasp, *Dielis ciliata*, and of *Ophrys fusca* [Fig. 4] *Ophrys lutea* and *Ophrys arachnitiformis* to solitary bees of the genera *Andrena*, *Colletes* and *Eucera*. In Australia, Coleman ... has found a similar relation of the orchid *Cryptostylis leptochila* to the Ichneumonid wasp, *Lissopimpla semipunctata*. [Fig. 5]. It is

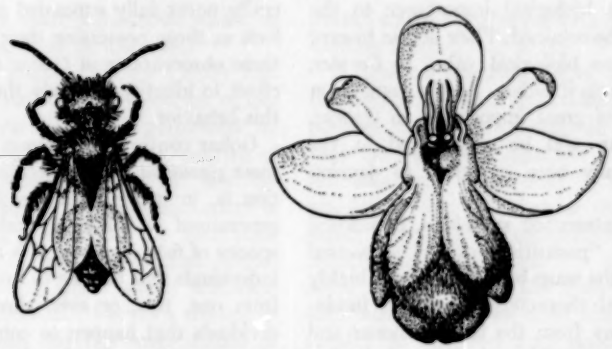

FIG. 4. LEFT, THE ANDRENID BEE, *ANDRENA TRIMMERANA*. RIGHT, A FLOWER OF THE ORCHID *OPHRYS FUSCA*, ON THE LIBELLUM OF WHICH THE BEE WILL MAKE COPULATION ATTEMPTS
Note the adaptation of the libellum, even to the extent of wing-venation. (After Ames.)

always the males that visit the flowers and fertilize them by carrying out the copulation act on the libellum. The flowers and especially the libellum resemble an insect very much, and Pouyanne could experimentally show that the sign stimuli releasing the attack of the insects are sent out by the libellum. As far as I know there is not much known of the stimuli releasing copulation attempts in Hymenoptera, but I happen to have had the opportunity to do some observations and experiments with males of the Sphegid *Ammophila adriaansei*. In these males motionless objects of roughly similar coloration and similar dimensions released copulation attempts, features therefore equivalent to those we find in the orchid libellum. Chemical factors do not seem to play a role. . . .

"The orchids are especially fertilized by the insects as long as the female Hymenoptera have not left the pupae (the males usually hatch a week to a fortnight earlier). During that time the males are likely to suffer from threshold lowering with regards to the sexual reactions; they will therefore more easily respond to non-adequate stimuli."

On the basis of this last statement one may wonder whether Baerends is not being delicate when he states that the orchids are parasitic on the wasps and that they *only* benefit from the association.

He continues: "The orchids need the insect to get fertilized; still they do not produce nectar or other food stuffs, but they make use of a releasing mechanism in the hymenopteron, a mechanism

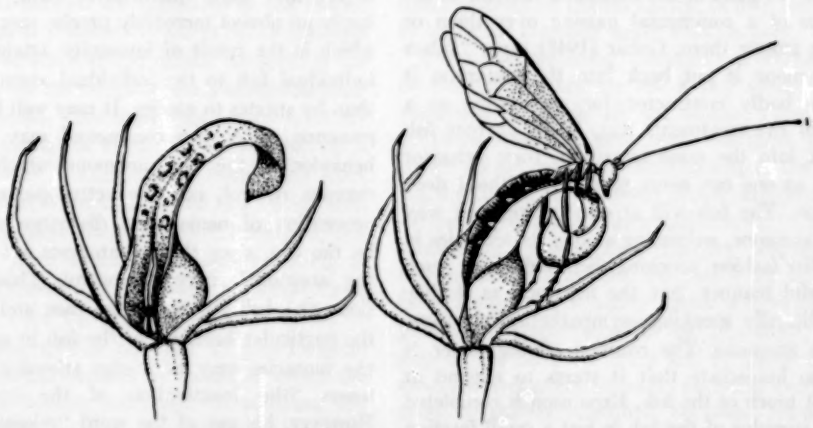

FIG. 5. LEFT, A FLOWER OF THE AUSTRALIAN ORCHID *CRYPTOSTYLIS LEPTOCHILA*. RIGHT, THE ICHNEUMONID WASP *LISSOPIMPLA SEMIPUNCTATA* MAKES A COPULATORY ATTEMPT
(After Ames).

that has so much biological importance to the insect that it will be retained. Their action toward the flower is of no biological value to *Gorytes*, but it does not harm it either. As the copulation act of *Gorytes* is of great importance to *Ophrys*, its releasing organ will be maintained in the flower, and we may even expect it to develop further."

This uniquely interesting symbiosis, depending indeed upon the "parasitization" of a normal behavioral act of the wasp by a flower with highly adaptive structural characteristics, differs fundamentally in no way from the far commoner and more widely known symbioses between the pollen and nectar-seeking higher hymenoptera and the flowering plants they cross-fertilize.

In the course of his discussion Baerends also points out for the first time the possibility that releasers are of importance in the maintenance of marine symbioses, particularly in such intimate and indeed "dangerous" associations as that of the giant anemones of the western Pacific and the fishes of the genera *Premnas* and *Amphiprion* that live among their tentacles. E. W. Gudger (1947) published a stimulating and complete review of the observations that had been made up to that time on this interesting partnership and posed a number of questions, none of which is yet answered. He asked: "Do the damselfishes and anemones recognize each other by chemical substances emanating from each?" Without analysis, the evidence seems to be that they do. Two investigators have independently observed that the tentacles of the anemones respond to the presence of a commensal passing over them or moving among them. Gohar (1948) says: "When the anemone is put back into the aquarium it remains badly contracted for some time as a result of the treatment. But, if the partner fish are put into the same aquarium, their behavior is such as one can never pass over without deep reflection. The fish will at once make their way to the anemone, swimming among its tentacles in a peculiar fashion, touching them lightly, in such a graceful manner that the fish look as if they were—literally speaking—sympathetically caressing the anemone. The reaction of the latter is often so immediate that it starts to expand at the first touch of the fish. Expansion is completed by the stimulus of the fish in but a small fraction of the time it would take without it. Besides, anemones deprived of their partner fish are generally never fully expanded and therefore do not look as those possessing their commensals." Since these observations of Gohar no one has made an effort to identify precisely the stimuli involved in this behavior.

Gohar continues: "Among all anemones *Discosoma giganteum* is very peculiar in that its association is, in many instances, but not always, not generalized to all individuals of the commensal species of fish. As a rule it is restricted to the very individuals that happen to live with them, whether from one, two, or even three species. Other individuals that happen to come in touch with the tentacles will at once be caught, paralyzed and in due course also devoured and digested. These may belong to the same species as its own commensal fish, which may be seen at the same time lying safely and happily among the tentacles. . . . How the anemone discriminates between the different individuals is difficult to understand." And, further: "The anemones appear as if they recognize their partners by their mode of movement. Thus they would sting and seize their own fish if the latter are passively pushed against their tentacles. Furthermore, the association between the anemones and their commensal fish lasts only as long as the fish are alive and healthy. Immediately the fish are dead or even moribund their partner anemone devours them, if it happens to be hungry."

These observations of Gohar are most interesting and significant, but one wishes they were supported by some discussion of experimental techniques and some quantitative data, since they imply an almost incredibly precise specificity, one which is the result of immunity attained by the individual fish to the individual anemone rather than by species to species. It may well be that the presence of its own commensal may alter that behavior of the host anemone which is under nervous control, but the active partner in any prevention of nematocyst discharge appears to be the fish, since the nematocysts are not under the anemone's nervous control. This Baerends (loc. cit.) believes to be the case and says that the particular behavior of the fish in snapping at the tentacles may be a sign stimulus which releases "the inactivation of the cnidoblasts." However, his use of the word "releases" implies the existence of a mechanism *within the anemone*, which when released, brings about the inhibition

of discharge. If any such mechanism exists in coelenterates, it remains to be disclosed.

Prior to Gohar's studies Vervey (1930) had published a detailed account of the ecology of this association in Batavia Bay, but performed no critical experiments to determine the identity of the stimuli eliciting recognition of the host by the fish or the mechanism whereby immunity is obtained. Concerning the former he had said: "It seemed probable to me that optical stimuli gave the first reaction, after which chemical stimuli settled the question." Vervey's studies in specificity are valuable, but the exact nature of the stimuli of recognition between host and commensal remains undetermined after twenty-five years. One could hardly imagine a partnership more admirably suited to critical controlled investigation.

The question of immunity to host nematocysts has numerous facets of significance which will have direct bearing on the successful establishment of all partnerships in which a stinging coelenterate is involved. Any specific behavior apparently involved in the acquisition of immunity must be studied in all such relationships as that between *Hydra* and the protozoan *Trichodina*, between hermit crabs and their commensal anemones, between jellyfish and their commensals, etc. In the case of the pomacentrids and their anemones as well as in others so far investigated there is some evidence that immunity results from the habit in commensals of "browsing" on the tentacles of host coelenterates. Cantacuzène (1925) thinks that this has effected the immunity of the hermit crab *Eupagurus prideauxi* to stings of the anemone *Adamsia*, and Kato (1933) thinks the same of the fish *Nomeus* to the stings of the Portuguese-man-of-war, *Physalia*. That there may not be total immunity in the latter symbiosis is indicated by a recent personal communication from Paul Zahl, who states that *Nomeus*, if placed in a bucket with *Physalia*, is almost instantly killed. Perhaps in this well-known team chemical substances serving to lower the threshold of discharge of nematocysts are absent from the integument of *Nomeus*, or perhaps some special behavior or physiological characteristic has evolved by means of which the fish actively inhibits discharge. In addition, the fish may avoid the tentacles or never come into more than delicate contact with them. It appears probable, according to Zahl's observation, that overall contact of *Nomeus* with the tentacles allows massive stinging and death.

A detailed investigation of the relationship of commensals to the host nematocysts in such partnerships would undoubtedly do much to elucidate their course of evolution. At the same time considerable light might thus be cast on the basic physiology and behavior of those much-investigated, supposedly independent effectors, the nematocysts. At any rate, it is obvious that in order to understand the behavior concerned in such associations, we must understand how immunity is acquired and maintained. The two problems are inextricably interwoven, as appears to be the case in the associations more familiar to the writer in which commensal polychaete annelids invade the stomachs of host starfish who may feed on other polychaetes! Recently, a wonderfully interesting association in which there must be combined specialized behavior to inhibit nervously controlled activity, resistance to digestive juices, and inhibition of nematocyst-discharge or immunity to their poison has been brought to the attention of the writer by Gunnar Thorson. In the waters off Greenland there occurs the gastropod *Sipho curtus*, on whose shell lives the anemone *Allantactis parasitica*. Under the foot of the anemone there may live the nemertean, *Nemertopsis actinophila* (Fig. 6). Thorson says: "The sea-anemone, though catching and digesting other species of worms, also nemerteans, which happen to touch its tentacles, will, without closing its pharynx or moving its tentacles, allow *Nemertopsis* to enter its gastral cavity, to feed there, and to leave the stomach again with its prey."

From the preceding discussion it should now be clear that there are few if any symbiotic associations in which all the stimuli determining adaptive behavior have been identified and in which all the behavioral acts leading to the bringing together of the members or the maintenance of the partnership are clearly understood. In a great number of partnerships nothing whatever is known of these factors. In nearly all in which there is evidence of highly specialized behavior of paramount importance to the symbioses, every step of the behavior must still be painstakingly analyzed and every stimulus releasing every step must be strictly identified. So much remains to be done that one may perhaps be forgiven for continually divorcing the problem of the analysis of behavior from any consideration of the eco-

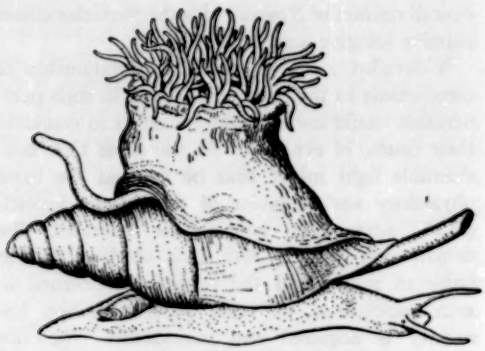

FIG. 6. A THREE-SPECIES ASSOCIATION OF GREENLAND WATERS

The nemertean *Nemertopsis actinophila* living between the foot of the anemone *Allantactis parasitica* and the shell of the host snail *Sipho curtus*. (After Poul Winther, courtesy Gunnar Thorson).

nomics of associations; and furthermore, it can hardly be denied that a clearer understanding of the evolution of partnerships, based on a knowledge of the control of specialized behavior of the members, has actually been delayed by teleological thinking concerning the economics of partnerships, in which the behavior of members has too often been passed off as a result of "need."

The above associations have been chosen merely as examples among the many partnerships about which we should know a good deal more than we do at present. Any number of other cases could have been employed. Even in the classic cases that appear in so many textbooks, such as the fish *Carapus* (Fierasfer) and its host sea-cucumber, or the commensal nereid worm and its host hermit-crab which has received popular treatment in Europe, behavior has only been described, not analyzed experimentally. In the latter case all we know is that when the worm enters the host's shell or feeds there is a standard pattern of behavior which results in the avoidance of the host's chelipeds. When entering (see Fig. 1), the worm glides over the spire and rapidly in over the dorsal lip of the shell between it and the dorsum of the crab. In feeding, after successfully moving its head over the "cheek" of the crab to a point among the mouthparts and stealing part of the crab's food, the worm snaps back like an elastic band to its point of safety in the spire (Thorson in Caullery, 1950; Brightwell, 1951; also pers. obs.). What manner of stimuli control this strict and wonderfully adaptive pattern of

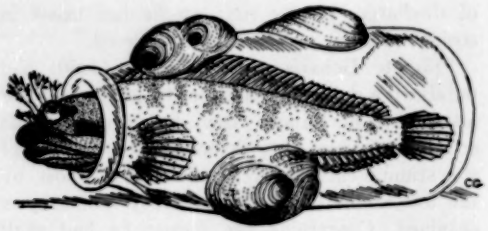

FIG. 7. THE FISH *NEOCLINUS UNINOTATUS*, WHICH FREQUENTLY INHABITS A COMMON ITEM FOUND ON THE BOTTOM OF SOUTHERN CALIFORNIA HARBORS

The bottle also provides a substrate for the limpet *Crepidula fornicata*. (From a photograph; courtesy of Andreas Rechnitzer).

behavior? In the case of *Carapus* and its host holothurian (see Fig. 2), a symbiosis widely known for more than a century, although the curious behavior of the parasite in entering the fish has recently been described in some detail (Arnold, 1953), the stimuli that elicit this behavior have not been identified. Some light might be cast on the behavior of *Carapus* were we to investigate thoroughly the behavior of the fish *Neoclinus uninotatus* that has a remarkable propensity for colonizing the bottles that dot the mud-flats under the shipping in San Diego Bay (Fig. 7). One may well wonder whether this behavior is governed by a thigmotaxis aided by the positive chemotaxis to bottle-contents exhibited by *Homo sapiens*!

SUMMARY AND CONCLUSION

We have considered at some length a number of types of symbiotic associations and have seen that without exception these partnerships exist as recognizable entities in the biota because one or both of the partners exhibit specialized behavior, the primary function of which is to effect and maintain the association. This behavior has been recognized and observed in some partnerships, but in very few have the stimuli eliciting it been precisely identified. Such stimuli which elicit behavior serving to effect and maintain partnership we may speak of in general as "symbiosis-effective" stimuli. It would seem that to date more attention has been given to the integrative action of chemical factors than to other types of stimuli. However, as critical experiments are performed with more partnerships it will undoubtedly develop that in many of them physical stimuli have primary integrative importance—such stimuli

as color, shape, texture, temperature, etc. It is probably impossible for any symbiotic association to exist without the normal functioning of such specific integrative factors, whatever their nature may be, any more than it is for the single organism to exist without the normal functioning of its coordinating mechanisms. Such integrative factors of a chemical nature have long been thought of as "social hormones." We must extend our concept of "trophallaxis" from the limited meaning used by earlier students of social organisms to a broader philosophical generality involving any specific stimuli which serve to maintain associations at any level of integration. Among the two-species associations known as symbioses, too many of these stimuli remain unidentified. Let us hope that in the future the obviously attractive possibilities in this field will release more "investigation-activity" among physiological ecologists and students of behavior.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

NATURE AND THE GREEKS. *Shearman Lectures, delivered at University College, London on 24, 26, 28, and 31 May, 1948.*

By Erwin Schrödinger. Cambridge University Press, New York. $2.00. vi + 98 pp.; ill. 1954.

At a time when science, philosophy and religion are at cross purposes, more perhaps than ever before, when research in physics is faced with what it has become fashionable to call a crisis, Erwin Schrödinger turns back to the beginnings of science in order to unearth "obliterated wisdom" and to discover "inveterate error." Science, he holds, is built upon the foundations laid by the Greeks. If their principles of an understanding of nature can be discerned, it should become easier to appraise certain characteristic features of the modern situation.

By way of introducing his determination of the main concepts of Greek science, Schrödinger first discusses the alternatives of a rational and empirical approach, as exemplified by Parmenides and Protagoras, and elaborates on the aprioristic outlook which led to the establishment of Pythagorean mathematics. He then singles out two assumptions as basic for the Greek interpretation of the phenomena. The one is the conviction clearly set forth already by the early Ionian thinkers (Thales, Anaximander and their followers) that the world can be understood by observing facts. The other assumption is to the effect that the construction of an objective picture of the world presupposes the exclusion of the perceiving subject; this seems implied in Heraclitus' epistemology.

What are the conclusions to be drawn from this historical exposé? The hypothesis that "the display of Nature can be understood" is to be retained. The positivist's contention, according to which natural science gives no more than a complete and economical description of the observed facts, is a "salutary antidote" against the over-confident belief that one has understood what in reality has only been described. Nevertheless it remains true that in certain respects the term "understanding" is appropriate, especially where a theory can be expressed in pure numbers. As for the exclusion of the observer, it is the necessary condition of any scientific analysis of the data of experience. At the same time it entails the consequence that science has nothing to say about man himself, about aesthetic or ethical values, or about human destiny. For it is only man's visible appearance, his body, that is part of

the world to be understood by science. The true self of man, his inner life, lies outside the framework within which science operates.

It is impossible here to evaluate the correctness of these conclusions. What Schrödinger has to say, I think, is a most important contribution, from the physicist's point of view, to the present debate on the meaning of science as well as on the relative merit of the scientific and philosophical approach to problems which once were called metaphysical. The author has discussed the same topics in their more general implications in his earlier article on "Die Besonderheit des Weltbilds der Naturwissenschaft" (*Acta Physica Austriaca*, I, 1948, Heft 3) and in his book on *What is Life?* (1946). Suffice it to say that, in my opinion, the issues are further clarified now that they have been set against their historical background.

To turn to the historical analysis itself, Schrödinger is surely correct in maintaining that for the early Ionian thinkers all matter, organic as well as inorganic, consisted of the same stuff; that its transformations were explained by rarefaction and condensation, a view elaborated upon by Anaximenes and akin to the modern view. It is not equally certain that the first philosophers and scientists, believing as they did that nature could be understood, based their insight on empirical observation. Dogmatic speculation on the evidence of a few facts rather than a patient study of the phenomena was the watchword of the rising scientific investigations; empiricism, as far as it was cultivated by the Greeks, was an achievement of the Hellenistic period. In his assumption to the contrary Schrödinger, I am afraid, has fallen under the spell of theories current among recent interpreters of Greek science, and advocated especially by B. Farrington. Yet there are good reasons for rejecting the claim that science originated from practical, and not from theoretical considerations. [Cf. L. Edelstein, "Recent Trends in the Interpretation of Ancient Science," *J. Hist. Ideas*, 13: 587 ff. 1952].

Schrödinger's acceptance of this claim also comes to the fore in a number of occasional remarks. To him, it is a "disconcerting fact" that the Pythagoreans with all their prejudices and preconceived ideas made better headway than the sober school of the Ionians. Plato is seen as the antagonist of scientific research. Such verdicts become superfluous if one is willing to acknowledge the share of speculative reason in the development of ancient science.

As regards the suggestion that in Heraclitus' epistemology the exclusion of the observer is at least hinted at, I find this conjecture most illuminating. That Heraclitus' concept of the "common" refers to the overlapping of individual sensations and experiences, I hesitate to concede. However that may be, Schrödinger has drawn attention to a trait in Greek science which is of decisive significance for its proper evaluation, even though the application of the principle involved, as he admits, was never consciously agreed upon. Nor should I deny that the Greeks themselves in their speculations on the soul violated all too often the principle on which they had founded their scientific endeavor.

The book contains other discussions of more specific questions that are of great interest. Above all there is the analysis of Pythagorean mathematics and astronomy and Schrödinger's conclusive demonstration that the ancient atomists cannot be considered the forerunners of modern scientists. The philosopher and the scientist, no less than the historian of science, will find a study of this little book most rewarding.

LUDWIG EDELSTEIN

ROUSSEAU: POLITICAL WRITINGS *containing the Social Contract, Considerations on the Government of Poland, and Part I of the Constitutional Project for Corsica. Translated and edited by Frederick Watkins. Thomas Nelson & Sons, Edinburgh.* 10s. 6d. xlii + 330 pp. + 1 pl. 1953.

No American should underestimate the influence of Rousseau, though less than that of Locke, in preparing the way for the memorable document that contains the words "... all men are created equal...." Biologists have been heard to criticize this charter of liberty because, they say, it is obvious that men are not created equal in strength, or color, or intelligence, to say nothing of wealth or power. Such critics fail to understand that Thomas Jefferson, and Jean Jacques Rousseau before him, were quite as well aware of these facts as any modern biologist. To find the true signification of the phrase, it is necessary only to go back to Rousseau's political writings, especially the *Contrat Social*, to discern that the guiding philosophy is rather that "the most ancient of all societies, and the only natural one, is that of the family"; that "since no man has natural authority over his fellow men, and since might in no sense makes right, conventions remain as the basis of all legitimate authority among men"; and that "if we assume that once men ... reached the point where the obstacles to their self-preservation in the state of nature are too great to be overcome by the forces each individual is capable of exerting to maintain himself in that state," then "their only means of self-preservation is to form by aggregation a sum of forces capable of overcoming all obstacles, to place these forces under common direction, and to make them act in concert." Hence there arises the *social contract*, whereby each man surrenders himself and all his rights to the community as a whole. "For, in the first place, since each gives himself entirely, the condition is equal for all...."

Now this may be a dangerous political philosophy, and even, from the viewpoint of modern anthropology, quite unsound—but it has nothing to do with genetic inequality or physical (read *racial*) differences. Where-

fore it would seem wise for biologists to read the present handy version of Rousseau's principal political views.

It is really a pity that the volume does not also contain Rousseau's *Discours: Si le rétablissement des sciences et des arts a contribué à épurer les Moeurs* (1750) and especially the *Discours sur l'origine et les fondemens de l'inégalité parmi les hommes* (1755), so that one could see the generation and modification of the ideas scientists are likely to find particularly interesting in Rousseau's thought. Incidentally, one may find very thought-provoking the rebuttal of some of the crudities of Rousseau's reasoning by Abraham Trembley (see review, p. 53).

BENTLEY GLASS

THE PERMANENT REVOLUTION IN SCIENCE.

By Richard L. Schanck. Philosophical Library, New York. $3.00. xvi + 112 pp. 1954.

The author, a member of the new Institute of Methodology which comprises specialists in various fields of science, believes that a new philosophy should undertake an important role in science and should act as a coordinator of research. He tries to show that there is a permanent general revolution in science, the new viewpoints of which were delivered especially by Marx's economics, by Freud's psychoanalysis, and by Singer's philosophy of science. The most essential viewpoint in the new philosophy is the shift from the individual as an element to a system of statistical relationships with self-development. This is shown by discussing some main problems of physics, chemistry, biology, psychoanalysis, psychology, sociology, and ethics.

The atom is found not to be an individual but a system. Trends which follow a class of causes with some stated regularity may be looked at as "teleological" relationships (without implying animism). Processes often develop themselves in the form of reciprocal actions, in which action and reaction may be simultaneous. In physiology, too, there are no net changes because equal and opposite processes move at the same rate. Cannon therefore speaks of a "fluid matrix." In psychiatry the pattern of the symptoms exists as a whole, and the same symptom may have an opposite meaning in two different constellations. Therefore Freud's method is statistical. In economics Marx stated a "continuous disequilibrium," and in ethics Singer's not attainable but approachable ideal is a relativistic but not a fixed absolute. "Faith, certitude and direction are found in our forward motion."

Besides these theoretical inquiries the Institute also develops operations research groups for industrial and community problems, in which problems of methodology form an integral part.

Of course such a relatively small book cannot discuss in detail the manifold problems mentioned. Hence some oversimplification and some limitation and partiality of opinions must be conceded.

B. RENSCH

SCIENCE IN SYNTHESIS. *A Dialectical Approach to the Integration of the Physical and Natural Sciences. Report of the Summer Session, July, 1952, of the Albertus Magnus Lyceum for Natural Science.*

By William H. Kane, Benedict M. Ashley, John D. Corcoran, and Raymond J. Nogar. Dominican College of St. Thomas Aquinas, River Forest, Ill. $3.50. x + 290 pp. 1953.

The Albertus Magnus Lyceum for Natural Science (of the Order of Friars Preachers) is an institute for the integration of the various branches of natural science through a critical analysis of their foundations. The present report of the summer session of 1952 shows the dialectical method applied: lectures by the Dominican fathers followed by discussions of all participants. As the historic tradition can shed light on unifying principles and methods, all discussions begin with historical summaries. The main conclusions are the following ones.

Physics, chemistry, biology, and psychology have their own basic concepts, but science does not yet possess a unifying theory. The analysis of the general structure of any natural science is also a problem of logic. Many questions which appear to be epistemological or metaphysical could in reality be disposed of at the level of logic. There is a strong tendency to apply a mathematico-physical method to all branches of the science of nature. But the authors believe that this mathematicism—even in modern physics—constitutes a return to a trend of thought which in former times led to a false "mysticism" or "scepticism" about the possibility of any genuine understanding of the natural world. Not only quantity but also quality is pretended to be an absolute characteristic of physical things, and quality cannot be measured.

Biology cannot be reduced to chemistry and physics, they hold, because the living organism is a unit and produces new units like itself. The causes of evolution still remain doubtful. It is not certain that natural selection is a sufficient cause of evolutionary changes and that mutations cause variations of a type which provides sufficient material for natural selection to produce the changes discovered by paleontologists. Cybernetics is capable of explaining the purposive and adaptive behavior of animals but it offers only a model. But such concepts run the danger of excluding the aspects of psychological behavior. Mental disorders are not diseases of the intellect, but of the instruments of the intellect. The authors believe that the most fruitful approach in all branches of the science of nature would be to trace certain fundamental concepts—such as con-

tinuum, time, space, life, structure, etc.—back to their historic origins.

It does not seem very probable that all scientists reading this book will agree to the dialectical method applied and to all the sceptical statements made herein, but in spite of this the whole discussion is of interest, and some critical remarks—especially those concerning the psychological aspects and the logical foundations—should be taken into consideration when problems of the philosophy of nature are to be discussed.

B. RENSCH

READINGS IN THE PHILOSOPHY OF SCIENCE.
Edited by Herbert Feigl and May Brodbeck. Appleton-Century-Crofts, New York. $6.00. ix + 811 pp. 1953.

READINGS IN PHILOSOPHY OF SCIENCE. *Introduction to the Foundations and Cultural Aspects of the Sciences.*
Arranged and edited by Philip P. Wiener. Charles Scribner's Sons, New York. $5.50. x + 645 pp.; ill. 1953.

These two anthologies furnish one of the best bases for the question: is there a philosophy of science? Both volumes are handsomely bound, and the editors of both have displayed considerable care in the choice of the articles which are reprinted. The volume edited by Feigl and Brodbeck is subdivided into 8 separate sections. These are: The Nature of Scientific Method; Philosophy of the Formal Sciences; Space, Time, and Relativity; The Logic of Scientific Explanation and Theory Construction; Causality, Determinism, Indeterminism, and Probability; Philosophical Problems of Biology and Psychology; Philosophy of the Social Sciences; and Epilogue. It is doubtful whether anyone except a specialist in each of these fields could completely digest and understand the implications and rhetoric involved. The inclination of the peruser ignorant of the formal treatment given to his avocation is instinctively antagonistic. This annoyance has two foundations. The first is a deep-seated distrust of verbal representations of physical problems and principles. The second is an unhappiness with the many occasions on which verbal logic has led to erroneous or untestable conclusions. One invariably gets the impression in reading volumes of the present type that the authors have little conception of the actual mechanics and attitudes of experimental scientists. One also feels that the writing frequently is not so much devoted to the untangling of complicated relationships among physical objects or theories as it is to the formulation and solution of essentially untestable hypotheses.

Biologists are perhaps, more than any other group of scientists, dependent upon intuitive and unformalized views as to the nature of the world and life. Some of these views have been so regularly ingrained in the texture of biological experimentation that it is difficult to consider objectively propositions that originate either in pure philosophy or in philosophic extensions of physical theory. Thus, to a biologist, the Galilean concept of the addition of velocities is a natural consequence of his daily observation. He sees nothing contrary to this rule within his experience. Likewise, where would his science be if he had assumed as a first principle a lack of precise relationship between preceding and succeeding events?

Finding himself faced with a fundamental contradiction to his own "common-sense" experience, the biologist is generally posed an impossible choice. Either he must ignore the more learned counsels of his philosophically inclined contemporaries in the marginal fields between physics and philosophy, as well as in philosophy, or he must accept without critical understanding uncomfortably alien points of view.

In both of these volumes there is considerable discussion, by a variety of writers, of the philosophical implications of relativity and the influence of quantum-mechanical concepts on the concept of causality. Perhaps the most illuminating feature of these various treatments is the lack of unanimity in their conclusions. The ultimate pictures presented range in the case of the problem just stated from a completely indeterministic view to one more cautious and less dogmatic. In the sense that "authorities" (e.g., see D. Bohna, *Phys. Rev.*, 85. 1951) cannot find themselves in agreement with respect to the eventual implications of physical theory, it is perhaps not too late to suggest that biologists might maintain an attitude of "watchful waiting" with respect to these questions.

The other volume on the philosophy of science, edited by Wiener, is subdivided into only 4 portions. One is the foundation of Mathematical and Physical Science; the second, Basic Biological and Psychological Concepts; the third, the Method and Problems of the Social Scientist; and the fourth deals with Philosophical Analysis and Synthesis. Several of the selections in this book are also printed in the other volume. In my own opinion, the volume edited by Brodbeck and Feigl contains a better selection of material than that edited by Wiener, at least in the biological and physical fields. If a criticism is to be leveled objectively against both sets of editors, it is that the task was perhaps too difficult. Treatises on such weighty subjects are frequently stilted, and, in the case of writers whose backgrounds are not largely experimental there is an obviously greater satisfaction with words and less preoccupation with experiment than appeals to the experimentalist.

As a source of interesting, if controversial, reading matter, both volumes are to be recommended. But if the prime objective was the clarification of personal insight into the scientific method, its problems and its possibilities, I do not feel that the attempts were successful.

BERNARD L. STREHLER

FROM FISH TO PHILOSOPHER.

By Homer W. Smith. Little, Brown & Company, Boston. $4.00. xv + 264 pp.; ill. 1953.

It will, I trust, not be considered unkind to observe that *From Fish to Philosopher* presents evolution from the standpoint of kidneys and the weather. This is the first of Homer W. Smith's books which I have encountered. If his other works also are characterized by the keen style, amusing side glances, and stimulating speculation which this book contains, the author's reputation as an expert and articulate popularizer of science is well founded. *From Fish to Philosopher*, after a solemn dedication to "Blitz, (1937?–1951)," begins with a discussion of the origin of the earth and the geological transformations which led to its being a suitable home for, and possibly birthplace of, life. In the second chapter there is discussed briefly the main outline of the nature of, and causative factors in, biological evolution. Mutation and the realignment of mutants through various segregation mechanisms are very briefly discussed. The lack of internal directional properties in the evolution from lower to higher forms is emphasized and the overall process is pictured as a selection of those genes in a variable gene population which possess the highest viability in a specific environment. It appears that the author might have spent more time in a discussion of isolation and population size as possible factors in macro-evolution.

A tier of chapters (early interrupted for a discussion of the kidney) follows, in which the main physical agents causing an evolutionary drive toward the most interesting, constructive, and destructive of all evolution's products, man, are presented. These chapters, which cannot be reviewed in detail, are liberally sprinkled with sometimes amusing, sometimes pointed, insight. For example, "The evolutionary 'missing link' between the ape and man was for long so conspicuous by its absence that it became a subject for jokesters who had a gap of their own to fill." And in discussing the highly complicated design problem in achieving locomotion he quotes Mrs. Edward Craster:

> "The centipede was happy quite
> Until a toad in fun
> Said, 'Pray, which leg goes after which?'
> That worked her mind to such a pitch,
> She lay distracted in a ditch
> Considering how to run."

The final and, I believe, most novel and interesting chapter discusses the problem of consciousness. What thoughtful man has not at some time contemplated the navel of awareness of awareness of self. Is it not an ironical turn of natural selection to implant an illusion of permanency mixed with self-regard, in the frail machine which carries it? Smith considers consciousness as a reflexive awareness of the perceiving organism by the perceiving organism of a continuing relationship between himself and his environment. He makes a considerable point of the fact that a necessary condition for consciousness is the spreading out of nearly instantaneous sensory impressions within the conscious center for a sufficient time to permit its correlation with other past, present, or future events. Thus consciousness can be considered a neural bridge superimposed upon the normal integrated mechanism of spatial and temporal summation. One might reasonably take issue with the author's suggested significance of sleep, which he feels is less a device to prevent neural fatigue than to permit muscular recovery. Since one cannot rule out a fatigue of nervous elements within some fairly restricted area of the nervous system, and since localized brain lesions in the hypothalamus are known to result in a loss of consciousness (e.g., sleeping sickness), one wonders whether his implied view of the brain being as a whole the conscious entity is tenable in fact.

The most momentous illusion of consciousness, the desire to rationalize objectively the feeling of subjective self-importance, is dealt with in the following way: "There are those who say that they can extrapolate from purpose in the organism to purpose in the cosmos, from personality in man to a personality transcending the stars and nebulae. This, also, I must deny. Purpose in the organism issues from its molecular structure, as does personality in man; and both are transient patterns in the swirling fountain of matter and energy that in a few thousand million years has spewed galaxies in inconceivable numbers and at inconceivable speeds into the impenetrable depths of space. It is scant modesty for man, even if he is the 'highest vertebrate' to presume that he can predicate the cosmic plan on the intensity of his joy or pain, or cement the stars together with even his highest aspirations."

BERNARD L. STREHLER

MAN'S UNCONQUERABLE MIND.

By Gilbert Highet. Columbia University Press, New York. $2.75. x + 138 pp. 1954.

This is a unique book, the product of a very competent Latin scholar who happens to be interested in the human mind and its development. Its subject matter is naturally treated historically; however, the author is uncannily versed in some of the modern concepts of neurology and psychology.

In almost poetical prose, man's conquest of nature, including his own, is portrayed in the first part, which deals with the powers of knowledge. The second part is more somber, warning the reader of the limits of knowledge. The third part is a dedication. In times of stress and confusion a hopeful note expressing man's faith in himself and his position in the universe is more than welcome. All this is done in a wholesome manner without the invocation of an "élan vital" or an "entelechy."

Gilbert Highet has an insight into man's complicated brain. He fully realizes that its 10 billion units are

united in a wondrous maze of combinations and permutations, making for an unlimited means of communication internally as well as permitting individuals to socialize to the fullest extent, especially by language. Language, of course, is stressed considerably, its invention, development, and perfection being one of man's supreme accomplishments. Modern communication liberates as well as controls man's thoughts and aspirations. The book bears out its title: the mind of man is unconquerable for long; and at no time completely conquerable.

PAUL G. ROOFE

THE SHOCK OF EXISTENCE. *A Philosophy of Freedom. By Robert F. Creegan. Sci.-Art Publishers, Cambridge.* $2.75. 140 pp. 1954.

Among the many disappointing products of existentialism, few can be as disappointing as this volume of exhortations, in prose and verse, on the theme of salutary shock. It is our duty as free men to discover that all fixities are absurd and consequently to feel an insatiable hunger for new orders in knowledge, art, and the conduct of affairs. Creegan gives this fashionable doctrine a rhetorical form in the manner of Nietzsche, and attempts to support it by referring to the analytical methods of pragmatism and semantics. None of these tries is successful; there is none of the orator's command of language, and no analysis of any particular action or word. Nevertheless, these vigorous pages are clearly successful speech and action of a certain kind, the kind that shocks a lethargic class-room into thought. "To be is to be deceived"; "all obsessive production has a status-referent motivation"; and "property rights are delegated experimental rights": these are epigrams that work in such a situation, and they are true if they truly shock. There is the danger that they will indoctrinate. In this respect there is one thing that must be said: the author's dependence on Nietzsche leads him much too frequently to use the language of capital sanction. He looks "death-smiling" on his enemies the dogmatists; he threatens that "to all who hate more generous order . . . our sharing liberty shall mean death"; and he promises that "those who celebrate the miracle of fact shall dance over the corpses of the culture of denial." This is not healthful food for young minds.

WILLIAM SINZ

BIOLOGIA GENERALE.

By Emanuele Padoa. Edizioni Scientifiche Einaudi, Torino. L. 8,000. 708 pp.; ill. 1953.

Students of medicine in Italian Universities take a year course in "General Biology." This should furnish them with enough general biological information to suffice for an understanding of more specialized medical courses and, at a later stage, for medical practice. Professor Padoa's book is meant to serve as a textbook for this course as well as a guide for the layman who wishes to have a simple and comprehensive outlook on current biological views and problems. As the author points out, today's physicians should be able to talk with competence on problems of physics, chemistry, inherited diseases, plasmagenes, the reproduction of viruses, mechanisms of mutation and an even wider range of scientific subjects. The task of presenting the reader with a compact and understandable summary of current basic biological knowledge is undoubtedly difficult but the author has managed to do so beautifully. The book is divided into ten parts: Basic Traits of Living Organisms; Elements of Biophysics and Biochemistry; Metabolism; Reproduction; Embryology; Growth; Genetics; Evolution; Taxonomy; Ecology. The presentation is clear, effective and well illustrated. Certainly the presentation of subjects of particular interest to me is up to date and well thought through. And, mirabile dictu, the discourse is not only instructive but also entertaining because of the frequent witty remarks the author blends with scientific data. This trait should make the book especially interesting for the layman who wishes to enhance his biological knowledge. Thus, for example, in the closing paragraph of the chapter on the origin of man, Padoa writes: "We already are in a position to answer the question, Where do we come from? From brutes. Who are we? The highest product of evolution: among animals, Vertebrates; among vertebrates, Mammals; among mammals, Primates; among primates, Hominidae; among hominidae, Scientists and Craftsmen. Where are we going? Toward an even higher evolutionary level? Perhaps, for Man, having acquired knowledge and thus a free choice, will be able to control his own evolutionary course. But nothing can be stated in a definite way; I would rather repeat the sentence that Madame Letitia Bonaparte used to repeat with regard to her family's glories: Pourvu que ca dure . . . ."

This is a good book, well planned, well written and altogether agreeable, even when, or perhaps particularly when, the author tries to be disagreeable.

A. A. BUZZATI-TRAVERSO

MEDICAL SCHOOLS IN THE UNITED STATES AT MID-CENTURY.

By John E. Deitrick and Robert C. Berson. McGraw-Hill Book Company, New York, Toronto, and London. $4.50. xxii + 380 pp. + 1 chart; text ill. 1953.

It is well known that a university is an institute that has trouble with its medical school. This remarkable pathology peculiar to universities has really only developed within the past 50 years—for it is only within

the past half century that medical schools have gained university status. One of the curses of this disease is that it is very costly to treat. Within the last 25 years the expense of maintaining these pathological conditions has gone up to over 700 per cent—and they are still in the red.

It is now generally agreed that one of the major obligations of a School of Medicine is to carry on research. However, in some instances these activities have reached a point where the other duties of the school are jeopardized. Many medical schools are imbued with the idea that their main function to the community is "Service." This has caused much grief in many quarters. Some medical schools have assumed the burden of medical care and the operation of the community's hospitals. It is becoming increasingly difficult to convince the local citizenry that medical Service is not synonymous with medical education and that the best Service that a university school of medicine can render its community is to behave like a University School of Medicine, and not like a clinic of the Department of Public Health.

The finances of the Medical School is one of the major headaches of the University (or State, if the university is tax-supported). The term "cost of medical education" is today without precise meaning. It includes too many items not concerned with education and usually related to "Service." Any estimates of the cost of educating a medical student which are based solely on the budget of the school and the number of students registered is misleadingly high.

The activities of modern medical schools are of such wide scope, particularly in their "Service," that men have been chosen to direct their affairs primarily because of their administrative ability rather than for their knowledge of medical education. The result is usually a conflict between the faculty and the "dean" rather than effective teamwork. There are some notable exceptions where deans have been appointed who combine both scholarship and ability to administrate—but these are indeed rare.

The relationship between the medical school and its hospital is almost as difficult as its relation with the university. To create a proper educational environment, the school should control all appointments in the hospitals. In more than half the medical schools in the United States, the hospital controls the school. Result—a cold war. University-owned hospitals offer a solution—but then remember "Service," which means "administrators," which again means cold war.

Theoretically, the faculty of a medical school should be composed of dedicated men with a consuming desire to add to their own knowledge and with a deep interest in students. The number of "geographic" full-time faculty members in the clinical departments has been increasing. I am sure it is not necessary to define "geographic" to those who read this journal.

The welfare of a School of Medicine and the health and well-being of the community depend to some extent on the quality of its students. The admissions practices of schools today are in need of an overhauling. This does not mean that their Admissions Committees are not made up of competent men of integrity who try to work as intelligently as they can. The evaluation of an applicant is extremely difficult and cannot be attained solely by examining his college grades or the academic standing of his alma mater.

The present-day curriculum of medical schools is in need of revision. But, where and how, raises controversies that have already raged at two Teaching Institute meetings. The salaries that are paid today—well, better leave that unsaid. If you are interested in these and other troubles that a University has with its Medical School, get this report.

DAVID B. TYLER

THE THREAT OF SOVIET IMPERIALISM.

Edited by C. Grove Haines. The Johns Hopkins Press, Baltimore. $5.00. xvi + 402 pp. 1954.

The interest of this volume to biologists lies in its inclusion of a chapter, An Evaluation of Soviet Scientific Capabilities, written by Conway Zirkle and discussed by Lazar Volin. The chapter is quite brief, and will add little to a knowledge of the subject on the part of anyone who had read either Zirkle's previous articles on the subject or who is acquainted with the A.A.A.S. symposium on *Soviet Science* (1953). However, the present evaluation is up to date, well balanced, and admirably suited for those who have not previously studied the subject—undoubtedly a matter of the utmost significance to scientist and citizen alike.

BENTLEY GLASS

BIOLOGY: HISTORY AND BIOGRAPHY

ABRAHAM TREMBLEY OF GENEVA. *Scientist and Philosopher, 1710–1784.*

By John R. Baker. Edward Arnold & Company, London; [St. Martin's Press, New York]. $7.50. xix + 259 pp.; ill. 1954.

Abraham Trembley, immortal through the discovery of *Hydra* and its powers of regeneration, is today scarcely known to biologists beyond that bare fact itself. In this book, prepared with meticulous scholarship and infinite pains to make every facet of Trembley's personality, life, and work stand forth clear and complete, each of us can become fully acquainted with one of the greatest zoologists of that age of great naturalists, the 18th century.

Trembley was a cousin and frequent correspondent

of Charles Bonnet. Réaumur was Trembley's idol and exemplar, and from Réaumur Trembley gained much. Yet Trembley was not the least in this eminent trio. As a naturalist he was essentially self-taught. When, at the age of 30, he discovered his "polyp" and began that series of careful observations and ingenious experiments that brought him fame and set the learned world of Europe to talking for days of nothing else but the fabulous plant-animal that reproduced by budding and yet could walk and eat, and that could regenerate head or body when cut into fragments, he had been unable to complete his university training, and had become the tutor of the young sons of a wealthy Dutch gentleman.

Baker summarizes as follows the chief discoveries made by Trembley:

1. the asexual reproduction of animals (*Hydra*) by budding;
2. proof that this process is in fact asexual;
3. the occurrence of budding also in the Polyzoa and Annelida;
4. the demonstration that animals can be artificially multiplied by division;
5. the performance of the first successful grafts of animal tissues;
6. the union by grafting of two individuals into a single one;
7. the discoveries that protozoa multiply by fission and that they form colonies when the division is incomplete;
8. the first observation of cell division (the multiplication of a unicellular alga);
9. the description of the salient features of protoplasm, a century before Dujardin;
10. the first anatomical study of a polyzoan;
11. the first descriptions of *Stentor*, *Epistylis*, *Zoothamnium*, *Chlorohydra*, and *Lophopus*; and
12. recognition of the animal character of the polyzoa and the sessile coelenterates.

Trembley's exceedingly careful observations were matched by the beautiful drawings made by Lyonet under Trembley's direction; while nothing, for that time, could surpass the skill and ingenuity of Trembley's experimental procedures as his interest in processes, rather than in structure alone, led him to feed his *Hydra*, to cut them until they had regenerated as many as seven heads apiece, to graft them together, to turn them completely inside out, or to prove the connections between buds and parent polyps.

In addition to the minutest attention to Trembley's scientific work, Baker portrays quite as fully every other aspect of this admirable naturalist. Utter sincerity, complete modesty, unfailing kindness, and in his later years an intense devotion to the education of his children were Trembley's most outstanding characteristics. The reader follows him on his travels, sees his concern for the troubled political affairs of his fellow-citizens of Geneva, and reads from his several volumes of *Instructions d'un père à ses enfans* as to his religious views and his moral philosophy, wherein he took issue with his fellow-countryman Rousseau.

If sometimes the biographer's love for completeness of detail verges on the wearisome, and if his style—in this book more than in others he has written—seems documentary rather than inspired, one cannot mistake the author's warm admiration for Trembley; nor should one undervalue the excellence of this memorial. No great scientist could ask for more than to be so fully and inspiringly recreated for a later generation.

BENTLEY GLASS

THOMAS YOUNG. *Natural Philosopher 1773–1829. By the late Alexander Wood; completed by Frank Oldham; with a memoir of Alexander Wood by Charles E. Raven. Cambridge University Press, New York.* $6.00. xx + 356 pp. + 3 pl. 1954.

Thomas Young was called by his contemporaries at Emmanuel College "Phaenomenon Young," and his phenomenality, throughout his life, consisted in the extraordinary range both of his interests and accomplishments. Modern investigators in physiological optics are accustomed to applaud him for his recognition of the significance of astigmatism, for his explanation of the process of accommodation in near vision, and for his theory of color vision on which Helmholtz' subsequent work was founded. His interest in the eye led him towards his studies on interference, as a result of which he revived the undulatory theory of light for Fresnel to translate into modern terms. That these contributions, which alone suffice to assure him a high position in the ranks of brilliant scientists, reflect but a minority of his achievements is best attested by a list of the articles which he wrote for the Supplement to the 4th edition of the *Encyclopedia Britannica*. In addition to many on medical topics, he provided articles on Annuities, Bathing, Bridge, Carpentry, Cohesion, Chromatics, Egypt, Fluents (Integrals), Herculaneum, Hydraulics, Languages, Life Preservers, Roadmaking, Steam Engine, Tides, and Weights and Measures. He wrote on these subjects as no mere dilettante: he was for a time, for instance, Superintendent of the *Nautical Almanac* and Secretary of the Board of Longitude, he was Inspector of Calculations of the Palladium Insurance Company, and he performed inquiries into weights and measures and their standardization as a member of a Commission appointed under writ of Privy Seal. He was a most distingiushed linguist from his childhood, one on whose preliminary work in deciphering the hieroglyphics and hieratics of the Rosetta Stone rests the more complete achievement of Champollion.

The career of this member of the Society of Friends, who started his professional life as an unsuccessful physician, to climb to a Professorship at the Royal Institution and the Foreign Secretaryship of the Royal

Society, stands as incontrovertible evidence for the theory that the truly great mind excels in various directions. The facts of his career are included in this biography, but they are cumbersomely presented in a volume which is not organized for easy reading. The personality, furthermore, which gave integrity to the extraordinary mind is not satisfactorily illuminated. The book nevertheless remains extremely useful for the specific information that it includes concerning one of the most phenomenal of universal intellects.

JANE OPPENHEIMER

THOREAU.

By William Condry. Philosophical Library, New York. $3.50. 114 pp. + 1 pl. 1954.

There are a number of books on Thoreau's life. This short biography is published in the centenary year of the publication of *Walden* by the immortal American naturalist. It treats briefly of Thoreau's associations and friendships, particularly those with Emerson and Hawthorne. It also touches on the famous causes he fought for, particularly his hostility toward unjust government. Here we have a sketch of the background that led to his writing his famous outburst on civil disobedience, which was probably the fountain-head of all passive resistance movements, and which particularly inspired Mahatma Gandhi. I have enjoyed reading this little biography of one of America's great idealists, and am glad to recommend it as a well-written document.

DAVID B. TYLER

AN AUTOBIOGRAPHICAL STUDY.

By Sigmund Freud; authorized translation by James Strachey. W. W. Norton & Company, New York. $2.50. 141 pp. 1952.

As the centenary of Freud's birth approaches (in 1956) this short "autobiography" takes on renewed interest. It is more nearly a concise account of Freud's life work in his own words, though, as is true of many geniuses, his life was peculiarly his work. First published in Leipzig in 1925, a brief postscript was added in 1935 for the 1st American edition. After just a page of personal data, Freud plunges into an account of his early anatomical and physiological studies with Brücke and Meynert and tells how he passed from these researches to the study of nervous diseases. Out of this came his work on the new drug cocaine, and the later published material on aphasias.

An opportunity to study with Charcot in Paris turned him away from the organic to the functional diseases of the nervous system, and once settled in Vienna he undertook the arduous task of making sense out of that confused field. An extremely hard worker, Freud quickly passed through the use of hypnosis, and of electric stimulation of the peripheral nervous system, and with great assistance from Breuer, to the latter's "cathartic" method of treating hysteria.

When he describes his ten years of work in isolation from the general stream of psychiatric work in Vienna, Freud's characteristic bitterness is apparent, and as he describes his later work and the dropping away of some recent disciples, the book takes on a polemic tone. However, there is developed a valuable, though extremely condensed, account of the evolution of the major Freudian ideas; and an additional chapter outlines some of the remarkably varied fields in which these ideas took root and quickly grew to practical application. Read in conjunction with Ernest Jones' recent biography, the present small volume provides a concise and factual outline of the life-work of a man who revolutionized psychiatry.

JEROME HARTZ

WILLIAM H. WELCH AND THE RISE OF MODERN MEDICINE.

By Donald Fleming, edited by Oscar Handlin. Little, Brown & Company, Boston. $3.00. vi + 216 pp. 1954.

When Welch, at 22, entered the College of Physicians and Surgeons in New York as a student, that institution was "legally," but hardly more than that, a part of Columbia College. It was the "oldest and best and most arrogant of the three quarrelsome medical schools in New York City. The others were that of New York University—actually a proprietary school which bought diplomas from the university—and the Bellevue Hospital school. If the University and Bellevue schools were inferior to their great rival, this was not because Physicians and Surgeons had raised a standard to which the wise and foresighted could repair. It was a good school of a bad kind, a business enterprise with no admission requirements, an ungraded course, a single examination at the end of a man's studies, and a healthy respect for Gresham's law of proprietary medical schools—not to raise one's standards very far above the level of one's worst rival because there would be no standard to maintain if the students took their fees elsewhere." Although these schools had some good men on their faculties, the faculty of most proprietary schools were more concerned with their fees, their practice, and their "reflex" (consulting fees obtained on the recommendations of former students), rather than with their teaching. The only enduring tradition in these institutes of higher learning at that time was human dissection. Little was required of the student in attending clinics and, other than anatomy, laboratory courses were non-existent.

However, at this time dramatic scientific developments were occurring in French and German labora-

tories, particularly in the latter. The discoveries in pathology and bacteriology could not help but alter the prevailing concept of the nature and treatment of disease, despite the opposition of the entrenched ignorants.

Welch, who was born shortly before the great transformation, was undeniably, by his position alone, a figure of importance in the development of medical education in the United States. In this friendly and not too critical biography, Fleming, with editorial assistance from Oscar Handlin, gives the background of the role played, in part, by Welch in bringing about the decisive change in American medical education that occurred at this time. Here also is presented quite briefly the influence on Welch of the scientific and medical developments in the European laboratories of Ludwig, Cohnhein, Weigert, Virchow, and Koch, where Welch had spent short periods as a student. In developing the main theme, the founding of The Johns Hopkins Medical School, there are some very excellent character sketches of a few of Welch's celebrated colleagues, particularly Osler, Mall, Halstead, and Kelly. The background of the famous controversy between Osler, on the one hand, and Mall, on the other, concerning "full time" for clinical professors is, I believe, one of the highlights of this book.

Medical education today is again on the verge of a transformation. There is a question in the minds of many about the direction it will take. Some fear that we may go back to a condition that will not differ fundamentally from what was found in proprietary schools of the 19th century. It seems to me that some of the problems that confronted medical schools and educators in Welch's day are again rearing their heads, but now under high-sounding names and other disguises. I believe that others who are concerned with recent trends in medical education may also recognize certain similarities.

DAVID B. TYLER

FIFTY YEARS OF MEDICINE.

By Lord Horder. Philosophical Library, New York. $2.50. 70 pp. 1954.

This is the published version of three Harbeen Lectures delivered by the author at the Royal Institute of Public Health and Hygiene. It consists, for the most part, of personal reminiscences.

MEDICAL RESEARCH.

Edited by F. H. K. Green and Gordon Covell. Her Majesty's Stationery Office, London. 40s. xvi + 388 pp. 1953.

Here is a rather belated report of the medical research activities of the United Kingdom during the last war. The British publication is similar to the 2-volume edition prepared in the United States by various members of the Committee of Medical Research, Office of Scientific Research and Development, and entitled *Advances in Military Medicine.* Its contents deal with research carried out under the auspices of British investigators on such problems as The Safety and Efficiency of the Fighting Man, Wounds and Injuries, War Diseases, Nutrition and Malnutrition, Public Health, Sulphonamides; and the Development of Penicillin, Industrial Health, Biochemical Research, Chemical Defence Research, and The Biological Effects of Explosions.

DAVID B. TYLER

THE YOUNG NATURALIST

LIFE ON THE EARTH.

By Rose Wyler and Gerald Ames. Henry Schuman, New York. $2.50. 144 pp.; ill. 1953.

The intelligent presentation of scientific knowledge is difficult enough at an adult level, but it is even more so when the audience is juvenile. Only the broad outlines can be sketched, and statements tend to take on a finality not necessarily intended. There is also a greater need for positive answers at this level when, ofttimes, no ready answers are available; all too often the half-truth or the speculation is provided without qualification. The present volume, dealing with the origin, evolution, and complexity of life on earth, and culminating with a statement on Man, Master of Life, does not succeed in avoiding these pitfalls even though the text is readable and, so far as it goes, informative. The many assumptions, stated as fact, make this a volume one would hesitate to recommend.

C. P. SWANSON

HUNTING WITH THE MICROSCOPE. *A beginner's guide to exploring the microworld of plants and animals.*

By Gaylord Johnson; with additions by Maurice Bleifeld. Sentinel Book Publishers, New York. 75 cents (paper). 132 pp.; ill. 1953.

A microscope is a rather expensive part of a young naturalist's equipment, but there is little doubt about the exciting world which it can reveal to the imaginative and inquiring youngster. When one becomes available, however, the need for adequate instruction and guidance is obvious, and this small volume has this purpose in mind. It is well written in an enthusiastic yet sound manner, and the illustrations nicely complement the text. It, or a similar text, should accompany the purchase of any microscope for the beginner.

C. P. SWANSON

ECOLOGY AND NATURAL HISTORY

PRINCIPLES OF GENERAL ECOLOGY.

By Angus M. Woodbury. The Blakiston Company, New York and Toronto. $6.00. viii + 503 pp.; ill. 1954.

Woodbury planned his college textbook of general ecology for the upper-division level. Its three parts deal with general considerations (including a chapter on historical perspective), the physical environment, and biotic interrelationships, respectively. The treatment of the physical environment includes much important material about which undergraduates should learn but which they may have trouble finding elsewhere in a conveniently accessible and readable form; and examples of the effects of physical environment upon living things furnish a background for the discussions of biotic interrelationships to follow. The text is concluded, appropriately, with a sane chapter on ecology and human affairs—and the author is not afraid to tackle the touchy subjects of human over-population and birth control.

PAUL L. ERRINGTON

THE "ROSAURA" EXPEDITION. *Bull. Brit. Mus. (nat. Hist.), Zool., Vol. 2, No. 6.*

The British Museum (Natural History), London. 30s. (paper). Pp. 115–239 + 4 pl.; text ill. 1954.

In 1937–38 Lord Moyne cruised the Caribbean and central Atlantic in his yacht Rosaura, with John S. Colman as zoologist and the winch from the Discovery I. Some of the minor results of the cruise have been published incidentally, and a narrative account, *Atlantic Circle*, was written by Lord Moyne. In the present collection there are 5 papers: Gear, Narrative and Station List (J. S. Colman); Under-water Illumination and Ecology in Tropical Estuaries (J. S. Colman and L. H. N. Cooper); The Echinodermata (D. D. John and A. M. Clark); Fishes, Part I (Denys W. Tucker); and Sponges (M. Burton).

JOEL W. HEDGPETH

WESTWARD HO WITH THE ALBATROSS.

By Hans Pettersson. E. P. Dutton & Company, New York. $4.00. 218 pp. + 29 pl.; text ill. 1953.

This is an account of the Swedish deep sea expedition of 1947–48, which lasted about fifteen months. The expedition crossed the Atlantic Ocean to Panama, the Pacific, Indian, and Mediterranean Oceans, and finally returned to Sweden. The route was an indirect one that allowed visits to sites of oceanographic interest—the Mindanao Deep, Hawaii, Tahiti, etc.

One of the primary objects of the expedition was to draw deep-sea core samples, and the description of the methods used and the interpretations made from the cores drawn in various deeps are an interesting feature of the book. The discussions of this and other scientific and technical matters—sea bottom sedimentation, radioactivity levels in sediments, or meteoric debris in the sea bottom—are illuminated by the interest Pettersson himself has in the subjects. Although the itinerary and events of the expedition are intrinsically fascinating, that fascination is somehow unexpressed in the book itself.

ALAN D. CONGER

A LA RECHERCHE DU MONDE MARIN.

By Pierre de Latil and Jean Rivoire. Librairie Plon, Paris. 990 fr. (paper). ii + 384 pp. + 32 pl.; text ill. 1954.

This is a rambling, digressive history of diving, from Oppian's divers of antiquity to the intrepid explorers of the bathyscaphe. It is full of delightful and interesting illustrations of sea monsters, quaint diving devices and the like, and there are also some rare photographs, such as the self portrait by Louis Boutan in 1898 (one of the first under-water photographs) and a view of the bathysphere of 1899. The senior author has published several books on marine life, and pays special attention to the use of diving gear by naturalists. He also devotes more space than an engineer may think necessary to some early ichthyological errors of Rondelet and to what Rabelais thought of Rondelet. Because of this interest of Latil, however, this history of diving is especially valuable for the biologist who may want to find out something about such matters as the pioneer submarine explorations of Milne Edwards and Quatrefages, made with the first diving suits more than a hundred years ago.

JOEL W. HEDGPETH

TO HIDDEN DEPTHS.

By Captain Philippe Tailliez. E. P. Dutton & Company, New York. $5.00. 188 pp. + 45 pl.; text ill. 1954.

Books about the use of the aqualung are now a standard product: they include chapters about early diving experiences, spearing fish, salvaging ancient wrecks, and the like, and are illustrated with photographs of undersea life, fishes on the end of a spear, old wrecks and other divers, some of them in color. (In this book the color plates are not as well printed as in the French edition, and several double-page plates are folded precisely through the center of interest in both editions.) There are also a few drawings, and a literary apostrophe to Neptune or somebody. This book, a somewhat later model, has some chapters about the bathyscaphe. Dozens of these books have been published as paper-backs

in France, where diving is evidently a national pastime, and several of them have been translated into English (not very elegantly, it must be said). So far, only two or three of these books have been written by naturalists, and for those of us who for one reason or another cannot use this wonderful diving device, the scientific information from all this activity remains meager. This book is typical of the genre, with misspelled names and haphazard zoology (e.g., the Globicephala are called "sea cows" and are referred to the "balaenoptera"), but for those to whom diving is an obsession, it will be "not without interest." It lacks an index.

JOEL W. HEDGPETH

THE FABULOUS INSECTS.

Edited, with an introduction, by Charles Neider. Harper & Brothers, New York. $3.50. viii + 278 pp. 1954.

INSECT FACT AND FOLKLORE.

By Lucy W. Clausen. The MacMillan Company, New York. $3.50. xiv + 194 pp.; ill. 1954.

The enormous variety of life in the Insecta provides species which to man are a source of equally varied emotions. There are examples of beauty as well as of hideousness; some amuse while others engender fear, anger or disgust; some give comfort, others varying degrees of discomfort; some are of enormous benefit, others of equally enormous destructiveness. When understood in all of their devious aspects, however, there are few species which are uninteresting and many which are amazing. It is little wonder, therefore, that the insects have been the subject matter for some of our best nature writers as well as symbols for folklore and legend. In the first of these two books, Charles Neider has gathered a number of already published stories about insects which have captured the attention of observant men: Fabre, Beebe, Maeterlinck, Peattie, Teale, Devoe, and others. Each is a story which will bear rereading many times, for each is an example of scrupulous observation, accurate reporting, and excellent writing.

Lucy Clausen's book is couched in more familiar terms. She is more particularly concerned with the relation between insects and man, a topic she approaches by considering the various orders of insects and the roles, both real and imagined, which these play in man's society and economy. At all times the treatment of superstition and folklore is set against a background of sound scientific knowledge. By a judicious weaving of fact and fancy she has succeeded in bringing entomology into closer union with anthropology while at the same time she has preserved a light and readable style.

Both volumes can be highly recommended, the first for its varied approach to the ingenuity, beauty and resourcefulness of insects, the second for its deft handling of an almost kaleidoscopic theme. Both are examples of popular scientific writing at its best.

C. P. SWANSON

A SEAL'S WORLD. *An account of the first three years in the life of a harp seal.*

By Frank Stuart, illustrated by Walter Ferguson. McGraw-Hill Book Company, New York, Toronto, and London. $4.00. viii + 226 pp.; ill. 1954.

Harp seals of the Arctic Atlantic are grouped in three main herds, in the Barents Sea, about Jan Mayen Island east of Greenland, and near Labrador. Each tribe performs its annual migration separately. The young are born on ice floes in March, are suckled for two weeks, and then abandoned by their mothers to fend for themselves. Sharks, killer whales, polar bears, Eskimos, seal hunters, nets and falling ice, all are dangers that the fortunate seal must learn to avoid if it is to survive the 3 to 5 years necessary for it to achieve sexual maturity.

The story is framed about the life of a female pup orphaned in an ice storm. Her wanderings transgress the usual tribal boundaries so that she meets in turn all of the related harp seal tribes, and encounters in turn all the peculiarities of survival with each group. The story is climaxed by her return to the original group, to find as her mate a marked male with which she had played as a yearling.

If the factual material of this book had been organized and written in the accepted scientific style it would be entitled "A Monograph on the Harp Seal." As actually written, it is a rare literary phenomenon—a book of accurate fact that is also extraordinarily good reading, written in the gripping style of an accomplished novelist.

BRYAN P. GLASS

THE WESTERN END OF LAKE ERIE AND ITS ECOLOGY.

By Thomas H. Langlois. J. W. Edwards, Ann Arbor. $10.00. xx + 480 pp.; ill. 1954.

This is a report by the Director of the Franz Theodore Stone Institute of Hydrobiology. It assembles the observations of the author on the area for the past 24 years, while he was Chief of Fish Propagation and Management in the Ohio Division of Conservation (1930–1946) and Director of the Stone Laboratory since 1936, as well as the published research on the Western part of Lake Erie. It is stated that this covers a period of 60 years, and that the primary aim is to supply a basis for a program of fish management in that part of Lake Erie under the jurisdiction of the state of Ohio. Its general application may be larger: "No other such large body of water has had any comparable long-term research program, so this use of the facts at

hand for interpretation of processes should be useful to all other hydrobiologists."

The central theme of this book is fish management. It is stated in the Preface, amplified in the Introduction, and occupies about half of the text. It was a surprise to learn that Ohio has a larger stake in the fish crop produced in the Great Lakes than any other state, that Lake Erie was the most productive of the Great Lakes, and that Americans catch 70 per cent of the total of fishes taken from Lake Erie.

Following an historical section dealing with hydrobiological studies of Lake Erie, there is a compressed section which deals with the physical environment of the lake. This is followed by a section on the plants and animals in Lake Erie, a section that treats the several taxonomic groups one after another, often in the form of an expanded and annotated checklist. Where data are available, there are summaries on distribution and species ecology.

The fisheries of Lake Erie and the subject of fish management occupy the remainder of the text. The former part includes a consideration of trap-netting, gill-netting, seining, pound-netting, angling, minnowing, and a discussion of the involved relationships between fishes and their physical and biotic environments. About 43 per cent of the fishes caught are piscivorous (chiefly yellow pickerel and blue pike) and about 56 per cent are bottom feeders (chiefly sheepshead, carp, and catfish).

The problem of fish management is stated and then the various methods are described, as, for example, regulated cropping, propagation, pollution control, the facilitation of fish migrations to and from tributaries, the improvement of land usage on the drainage area, and research. A new fishway design is described. There is a bibliography of about 450 titles and a general index.

ORLANDO PARK

WILDLIFE IN ALASKA. *An Ecological Reconnaissance. By A. Starker Leopold and F. Fraser Darling; sponsored by The New York Zoological Society and The Conservation Foundation. The Ronald Press Company, New York.* $2.75. x + 130 pp.; ill. 1953.

This small book has a broader scope than most prospective readers might judge from its title. It may be recommended not only to naturalists, conservation biologists, and sportsmen but also to economists, sociologists, administrators, congressmen, and anyone else sincerely interested in Alaska and Alaska's problems. It is a report on a survey, with the scientific limitations of a survey fully recognized and a realistic attitude maintained throughout. The survey in this case was centered upon the status of the native moose and caribou and the introduced reindeer and was carried on by two top-notch students of the world's Cervidae.

Emphasis is placed upon the fundamental ecology of the species that are of outstanding importance in the Alaskan picture and upon the dangers of neglecting range deterioration while allowing (or even encouraging) grazing animals to reach what amount to greater abundances than can be permanently supported. Notably serious—and too generally unappreciated by human observers other than specialists on such subjects—are the impacts of excessive overuse by both reindeer and caribou and of fires upon the slow-growing branching lichens that serve as the staple food for the reindeer and caribou.

The authors believe that wildlife resources will continue to occupy a place of dominance in Alaskan economy. They urge that management of those resources on a sound ecological basis be put into effect while the land still has enough of its native wildlife and wildlife habitat with which to work satisfactorily.

PAUL L. ERRINGTON

CORO-CORO. *The World of the Scarlet Ibis. By Paul A. Zahl; foreword by Joseph Wood Krutch. The Bobbs-Merrill Company, Indianapolis and New York.* $4.50. 264 pp. + 30 pl. 1954.

Coro-Coro is the tale of Paul A. Zahl's solo expedition to the state of Apure in the great inland plain area of Venezuela to observe the scarlet ibis, or coro-coro in the native language. A natural nesting area of the coro-coro is in the llanos in the environs of San Fernando on the Apure River, a tributary of the Orinoco, but numerous fruitless sorties were made by dugout canoe into the surrounding flooded areas before a nesting colony was finally found. Zahl found that the color and brilliance of the birds in their native habitat fully justified the extravagant descriptions that had been penned by earlier naturalists. It was, in fact, the extreme disagreement between the pale and scrawny appearance of the coro-coro which Zahl saw in captivity at New York, and the highly colorful text descriptions he had read about the bird, which initially induced him to make his expedition. The excellent photographs, one in color, incline the reader to agree that the bird is as beautiful as claimed.

Zahl writes with his customary fluent style. His description of the life and habits of the natives in this remote and rather primitive area, dry, grassy, and sparsely wooded in summer, flooded in winter (it sounds like the Everglades, except that the water is moving), is fully as interesting as the material about seeking and finding the coro-coro. The narrative is frequently interrupted by little speculative essays on evolution, speciation, the philosophy of parasitism and other biological

subjects, induced by some pertinent observation of the daily life.

ALAN D. CONGER

ERNEST THOMPSON SETON'S AMERICA. *Selections from the Writings of the Artist-Naturalist.*

Edited with an introduction by Farida A. Wiley, contributions by Julian M. Seton, and drawings by Ernest Thompson Seton. The Devin-Adair Company, New York. $5.00. xxiv + 414 pp. + 9 pl.; text ill. 1954.

Regardless of the side that one may take regarding the accuracy of the biological observations of Seton, no one will dispute his mastery of written English. This volume is essentially a "Seton Anthology," containing selections from the very best of his writings. Many of the essays selected are from his better-known works, such as the monumental *Lives of Game Animals*. Others are famous short stories, including such favorites as "Lobo, King of the Currumpaw," and "Krag, the Kootenay Ram." Some of the passages are excerpts from unpublished manuscripts, as are some of the illustrations. For those who love Seton's descriptions of America unspoiled, the living wilderness, this book is highly recommended.

BRYAN P. GLASS

DAS LIEBESLEBEN DER TIERE.

By Wolfgang von Buddenbrock. Athenäum-Verlag, Bonn. DM. 12.60. 252 pp. + 24 pl.; text ill. 1953.

This popular book, written for the laymen as well as for the biology student, contains chapters on reproduction among protozoa, sex differences, methods by which the males and females find each other, mating display, fights, pairing, copulation, hermaphroditism, and the rearing of the young. Each chapter has examples from the lower phyla and the arthropods, as well as from the different classes of vertebrates. The lack of an index and the absence of references limit the usefulness of this book. Only the list of sources of the illustrations supplies a hint as to where original material can be found.

HERBERT W. LEVI

EVOLUTION

ÉVOLUTION ET PHYLOGÉNIE CHEZ LES VÉGÉTAUX.

Centre National de la Recherche Scientifique, Paris. 2,200 fr. (paper). iv + 320 pp. + 1 pl.; text ill. 1952.

The various aspects of plant evolution pose innumerable problems, many of which were aired at the international colloquium held in the Muséum National d'Histoire Naturelle at Paris in May 1952. This slender, but comprehensive, volume presents the detailed record of specific, and for the most part illustrated, papers and the lively discussions which followed their presentation. Between the general introduction by R. Heim and some concluding meditations by G. Depape, there is spread a panorama of the diversified interests, approaches, and problems in plant evolution which must leave any student impressed both with the body of factual evidence and with the plethora of problems that are either unsolved or barely emerging. M. Chadefaud presents the evolution of the higher plants in terms of that of the algae; papers by R. Heim and E. Gäumann deal with evolution of the fungi; H.-J. Lam's with the evolution of vascular plants. Other presentations deal with the question whether the Psilophytales represent the melting-pot of the vascular plants (Suzanne Leclerq); the evolution and classification of gymnosperms; morphological relationships of stem, root, and leaf (L. Emberger); the evolution of the protective structures of the sporangium (J. Walton); the origin and evolution of the flower (T. Just); the evolution of ovule, pistil, and fruit (G. Mangenot); plant evolution and seedling anatomy (E. Boureau); the significance of juvenile forms in the study of evolution (Mlle. Y. de Ferre); pseudocyclic evolution (H. Gaussen); paleogeography, sociogenesis, and evolution (R. Potonie); morphogenesis, teratogenesis, and evolution (P. Chouard); the dynamics of evolution (W. H. Hiesey); the nominalistic aspect in modern evolutionary systematics (H. J. Maresquelle); evolution and heredity in plants (C. D. Darlington); and the history and significance of evolutionary theories in plants (J. Augier). These papers, which touch upon aspects of morphology, normal and abnormal growth, ecology, and genetics, should interest a wide circle of readers.

ROBERT BLOCH

PIONEER PLANT GEOGRAPHY. *The Phytogeographical Researches of Sir Joseph Dalton Hooker.*

By W. B. Turrill. Martinus Nijhoff, The Hague. Guilders 19.—. xii + 267 pp. + 21 pl. 1953.

The author, encouraged by Franz Verdoon, Editor of *Lotsya*, has made available through this well-printed and appropriately illustrated volume the essence of the pioneer publications in plant geography of one of the titans of the 19th century botanical world, Sir Joseph Dalton Hooker. This is not merely an account of Hooker's prodigious contributions to phytogeography, but also a critical appraisal of his works in the light of scientific advances, especially of the last half century. Carefully selected extracts and occasional sketches from journals written on excursions to then botanically un-

explored areas such as Nepal, Sikkim, Morocco, and remote islands of the South Pacific are interspersed skillfully with quotations from interpretive essays on floras and their origins. Turrill appraises Hooker's writings, save for continental North America, where he does not attempt a summary of contributions in the post-Asa-Gray–Hooker Period. Of special interest is a critique of Hooker's views on evolution and the origin of plant species as revealed in writings of the pre- and post-Darwinian years. One notes that nearly a decade prior to the publication of Darwin's *Origin of Species* in 1859, Hooker clearly comprehended the basic ideas of this epochal theory, which he outlined in the introductory essay to the *Florae Novae-Zelandiae* (1853-55). Moreover, Hooker foresaw that variable cultivated species presented an opportunity to investigate the laws of mutability, which Gregor Mendel quite independently studied with garden peas. Finally, a selected bibliography of references cited by Turrill is included.

This is a book which makes available for the first time in one volume the "meat" of the classic and more important phytogeographic contributions of Hooker. It is well organized, virtually free of typographical errors, and is an indispensable addition to botanical literature.

W. B. DREW

THE VERTEBRATE FAUNA OF THE SELMA FORMATION OF ALABAMA. *Part III. The Turtles of the Family Protostegidae. Fieldiana: Geology Memoirs. Vol. 3, No. 3. Part IV. The Turtles of the Family Toxochelyidae. Fieldiana: Geology Memoirs. Vol. 3, No. 4.*

By Rainer Zangerl. Chicago Natural History Museum, Chicago. Parts III and IV, $6.00 (paper). (III) Pp. 54-133 + 4 pl.; (IV) Pp. 137–277 + 21 pl. 1953.

Zangerl has used the occurrence of certain marine turtle species in the Selma Formation, Cretaceous of Alabama, as an opportunity to review two turtle families in a comprehensive fashion which involves not only striking advances and revolutions in the taxonomy of these families but also discusses important points in their anatomy and biology.

The treatment of the Toxochelyidae is the more successful of the two studies. In this case the material has been abundant enough and sometimes good enough that an almost complete osteology has been pieced together. Accordingly an important section discusses the osteology of the family, with a number of phylogenetic and biological points highlighted. The internal morphology of the braincase is described and found to be intermediate between that of the snapping turtles and that of the modern sea turtles. The cervical vertebrae are described not merely with regard to modifications of the central facets but with regard to length-zygapophysial breadth relationships, which seem also to have diagnostic value. A consideration of the limbs and girdles leads to a discussion of the use of limbs by sea turtles as compared with land and freshwater types and the adaptations for this use in each type. There is a table of comparisons demonstrating that in the limbs, as in so many regards, the toxochelyids are structurally intermediate between sea and freshwater turtles.

For the rest, the monograph of the Toxochelyidae is an extraordinarily careful taxonomic work which straightens out the sad tangle into which incorrect associations of fragmentary fossils had gotten us. There is revealed a remarkable phyletic series within this primitive marine turtle family. The series starts with forms with strong resemblances to the living snapping turtles and ends with forms with extraordinary secondary palates. A third group within the family—intermediate in the palatal condition—is specialized in having shells extravagantly tuberculate in the vertebral region.

The monograph of the Protostegidae is similarly careful and elaborate, but fails to be quite comparable for three reasons. Some of the more important material of this family is so mounted as to be unavailable for research. The material is intrinsically somewhat more difficult, less often articulated when found and less perfect. The third reason, however, is one of presentation. The write-up is not phyletic but stratigraphic and so is less easy to follow or to appreciate.

The two monographs together deal with an important chapter in the marine adaptations of an order which has several times invaded the sea. Further study of these invasions may be expected to bring forward much information of general evolutionary interest. Zangerl has here made a notable contribution to the inception of this fund of knowledge.

ERNEST WILLIAMS

THE COMPARATIVE MYOLOGY OF THE MAMMALIAN GENERA SIGMODON, ORYZOMYS, NEOTOMA, AND PEROMYSCUS (CRICETINAE), WITH REMARKS ON THEIR INTERGENERIC RELATIONSHIPS. *Misc. Publ. Mus. Zool., Univ. Mich., No. 83.*

By George C. Rinker. University of Michigan Press, Ann Arbor. $1.25 (paper). 124 pp. + 18 pl. 1954.

The objective of the study reported here was to determine whether or not comparative myology is a fruitful method of determining phylogenetic relationships. The results indicate that the classical methods of comparison, using cranial and dental characters almost exclusively, while convenient, may not always give a true picture of natural relationships.

Sigmodon was the genus most intensively studied, while the other three were described only in so far as they deviated from the "Sigmodon" pattern. Origin, insertion, topographic relationship, and innervation

were the main bases for the comparisons. Eighteen pages of figures supplement the text.

By treating all characters equally, and regarding the sum of similarities and differences as being indicative of true natural relationships, the author concludes that *Sigmodon* and *Oryzomys* constitute a closely related pair, as do *Neotoma* and *Peromyscus*. This differs sharply with the views obtained from cranial and dental studies, which relate *Sigmodon* with *Neotoma*, and *Oryzomys* with *Peromyscus*.

BRYAN P. GLASS

GENERAL AND SYSTEMATIC BOTANY

TASCHENBUCH DER BOTANIK. *Zweiter Teil: Systematik. 11th edition.*

Founded by Hugo Miehe; revised by Walter Mevius. Georg Thieme Verlag, Stuttgart; [Grune & Stratton, New York]. DM 8.90 (paper). xii + 180 pp.; ill. 1953.

The systematic section of this botanical handbook, which was founded by Hugo Miehe, contains a synoptic review of the entire plant kingdom. There are brief descriptions of the characters by which the divisions, classes, and orders are distinguished, and among the vascular plants the principal families are also described. The general arrangement of these units, and their taxonomic definitions, appear to be in substantial accord with modern thinking along these lines. Following introductory forewords to the 10th and 11th editions, there is a comprehensive table of contents which gives the organization of the plant kingdom as it is treated in the book. The entire work is profusely illustrated with line drawings of taxonomically definitive structures. At the close of the text are two diagrams showing, respectively, the probable evolutionary sequence among the principal plant groups, and the probable relationships among the orders of angiosperms. The book closes with an index to plant names and terms used in the text.

H. M. RAUP

WILD FLOWERS *and How to Grow Them.*

By Edwin F. Steffek. Crown Publishers, New York. $3.95. 192 pp. + 32 pl.; text ill. 1954.

In spite of the old official opinion that the best way of preserving wild flowers is never to pick them, increasing numbers of people have found in recent years that in many cases wild flowers are perpetuated and increased more efficiently in their own wild-flower gardens than they would be in the wild. It was with some relief, and a feeling of vindication, that I read at last a wild-flower book which expounds exactly this idea.

This is the best book on the subject—there are but few others—I have seen. Steffek starts off with a sensible and practical introduction on the general subjects of how to grow wild flowers, how to determine their preferences for certain conditions of light and soil, the best time to move them, and methods of propagation by seeds, division, cuttings, and so forth. There are two useful tables, one a compilation of the plants which will be found in certain easily recognized plant communities, and one that groups plants by their acidity preferences, pH 4–5, 5–6, and 6–8.

The bulk of the book is devoted to a consideration of various groups of wild flowers—the anemone clan, azaleas, fringed orchids, gentians, to mention a few. Each such plant group is divided into sections: description of the species, often with a small photographic inset, where they grow, blooming season, and culture and propagation. The sections on culture and propagation are the unique feature of the book, and the best. They are loaded with hints on requirements or preferences of the plants being considered, and tell for each the best, or easiest, or fastest method of propagation. Information is specific. For example, the author tells us that the fringed gentian is a biennial, and must therefore be propagated from seed.

The 32 color plates are well done, but must add unnecessarily to the cost of the book, since most purchasers will have already numbers of illustrated flower books.

ALAN D. CONGER

CHECK LIST OF NATIVE AND NATURALIZED TREES OF THE UNITED STATES (INCLUDING ALASKA). *Prepared under the direction of The Forest Service Tree and Range Plant Name Committee. Agriculture Handbook No. 41.*

By Elbert L. Little. U. S. Department of Agriculture, Forest Service, Washington. $2.00. ii + 472 pp. 1953.

This new *Check List* of scientific names and current synonyms, common names, and ranges of the native and naturalized trees of the United States and Alaska is an authoritative, up-to-date, and very welcome contribution to North American dendrological literature. Little's *Check List* replaces the out-of-print and antiquated *Check List* by Sudworth issued in 1927. Since the *Check List* of 1927 was based chiefly on the now obsolete "American Code," considerable changes have been necessary to bring the nomenclature of the present volume into harmony with the rules of the International Code of Botanical Nomenclature. In addition, the common names of American trees have, in the past quarter century, been much revised by the Forest Service Tree and Range Plant Name Committee. Contrary to the practice followed by the former *Check List* and most floras and manuals, which ordinarily list families according to some phylogenetic system, the trees (genera, species, important varieties, and named

hybrids) are listed in a single alphabetical order in the new *Check List*. A Botanical Index of Plant Families and Genera is, however, provided, and thus permits correlation of the alphabetical order with the natural arrangement of families and genera according to Dalle Torre and Harms. An Alphabetical List of Plant Families has also been inserted to aid in finding families in the Botanical Index of Plant Families. Although somewhat vexatious from the systematist's standpoint, the arrangement is well adapted to serve the book's primary function as a check list. Following each scientific name and approved common name is the synonymy in chronological order, derivation of the scientific name, other common names, range in outline form by states, a list of selected references, and a list of hybrids having binomial names. Finally, there are brief explanatory notes on nomenclature, particularly of recently changed scientific names or of confused or misapplied names. Foresters unfamiliar with revisions of the International Code of Botanical Nomenclature made at the Seventh International Botanical Congress at Stockholm in 1950 will doubtless be somewhat dismayed to discover that the new "typical varieties" rule has given birth, automatically, to such appellatives as *Picea glauca* var. *glauca* and *Pinus ponderosa* var. *ponderosa* for, respectively, white spruce (typical) and ponderosa pine (typical). Little, however, wisely suggests that in forestry practice, in cases where there is no risk of confusion, it will doubtless be simpler to retain present usage instead of typical varieties. Foresters, particularly in the Pacific Northwest, will also doubtless be dismayed to learn that the long established scientific name of the Douglas Fir (*Pseudotsuga taxifolia* (Poir.) Britton) has been rejected in favor of *P. menziesii* (Mirb.) Franco, by reason of priority.

SCOTT S. PAULEY

PLANT PHYSIOLOGY

ANNUAL REVIEW OF PLANT PHYSIOLOGY. *Volume 5. Edited by Daniel I. Arnon; associate editor, Leonard Machlis. Annual Reviews, Stanford.* $7.00. x + 399 pp. 1954.

The present volume of the *Annual Review of Plant Physiology* maintains a distribution between articles of theoretical and those of practical interest. The articles of Postharvest Physiology of Fruits and Vegetables (Pentzer and Heinze), Nutrition by Foliar Application (Boynton), Mineral Nutrition of Phytoplankton (Ketchum), Soil Conditioners (Quastel), Physiological Aspects of Fungus Disease of Plants (P. J. Allen), and the Role of Plant Physiology in Plant Geography (Mason and Stout) relate primarily to applied areas of plant physiology. More theoretical aspects are covered in articles by McElroy and Nason on the Mechanism of Action of Micronutrient Elements in Enzyme Systems, by Blinks on The Photosynthetic Function of Pigments Other Than Chlorophyll, by Goddard and Stafford on the Localization of Enzymes in Cells of Higher Plants, by Braun on The Physiology of Plant Tumors, by Brauner on Tropisms and Nastic Movements, by Samish on Dormancy in Woody Plants, by Lumry and Spikes on Photosynthesis, and by S. A. Gordon on the Occurrence, Formation and Inactivation of Auxins.

Not all topics are reviewed every year in this series. Among the articles of basic interest here, those by McElroy and Nason, Braun, Brauner, and Samish are especially welcome, since they present material and points of view that are covered relatively rarely in the Annual Reviews.

It is a pleasure to be able to say that conscientious and predominantly successful efforts have been made to maintain a high and critical standard of reviewing. In all cases, there is an attempt to present an integrated picture of plant processes, rather than an unevaluated summary of experiments performed.

A. T. JAGENDORF

ECONOMIC BOTANY

SOIL. *By G. V. Jacks. Philosophical Library, New York.* $5.00. x + 222 pp. + 11 pl.; text ill. 1954.

This stimulating book is by the Director of the Commonwealth Bureau of Soil Science at Rothamsted, the seat of the world's deservedly most famous center of soil science. The author, who is neither an earthworm enthusiast nor an organic farming crank, says, "The purpose of this book is to give the [British] farmer, the student of agriculture and all who realize the importance of the cultivation of the land an insight into the new science of soil management." The book thus endeavors to explain some important soil-plant relationships, and emphasizes the activities of man as a biological agent in soil development and utilization. It describes the historical background of English soils and how some of their important characteristics came about.

ROBERT L. PENDLETON

TROPICAL SOILS. *A critical study of soil genesis as related to climate, rock and vegetation. By E. C. J. Mohr and F. A. Van Baren; under the auspices of The Royal Tropical Institute, Amsterdam. N. V. Uitgeverij W. Van Hoeve, The Hague and Bandung; Interscience Publishers, London and New York.* $9.00. 498 pp. + 4 pl.; text ill. 1954.

The subject has been presented here from the fresh and

yet most logical *equatorial* standpoint, rather than from that of the temperate zone, European or North American point of view. Both authors have seen service in the former Netherlands Indies agricultural service. In that region many data are available regarding the climate, so that related observations are more significant. The senior author has been a pioneer in the mineralogy of soils, its significance in soil genesis, and its use in estimating the potentialities of soil fertility. Such practical considerations of soil use and management as erosion, irrigation and drainage of the soil, and the use of commercial fertilizers, amendments, and mulches are deferred to a subsequent volume. A vast number of papers and studies relating to tropical soils have been put into perspective in this book, and evaluated in a stimulating manner. This is indeed an indispensable book in pedology.

ROBERT L. PENDLETON

AMERICAN FOREST MANAGEMENT.

By Kenneth P. Davis. McGraw-Hill Book Company, New York, Toronto, and London. $7.50. xiv + 482 pp.; ill. 1954.

Forest management, like other applied sciences, is dynamic in its pattern and application. This up-to-date treatment of the subject of American Forest management is a valued addition to the McGraw-Hill Book Company's American Forestry Series, and is a fitting sequel to the late Professor D. M. Matthews' *Management of American Forests*, long a standard text and reference book for American forest managers. According to the author, a forest manager "needs to have the earthy and intimate forest understanding of the silviculturist, the long range viewpoint of the planter, the skills of the administrator, and the alertness, flexibility, and all-around resourcefulness of a successful business man." To qualify successfully for such a diversity of activity, the forest manager must necessarily be well grounded in the technological and biological aspects of forestry on the one hand, as well as the business and social aspects on the other. This general division of subject matter forms the basis of separation of the book into two parts. Part I is centered on the forest, and the concept of a regulated and continuously productive forest is discussed from the standpoint of site, stocking, growth, and yield. Part II is concerned with valuation principles and procedures applied to forest management problems. The author is of the opinion that valuation should be regarded as an indispensable and integral tool of management, since valuation judgments must, in the last analysis, act as a guide to a choice of possible alternatives. The book will find wide application as a text or reference book, since it is in no sense regionalized. The book is well indexed and contains a bibliography of about 250 citations.

SCOTT S. PAULEY

FIELD EXPERIMENTATION WITH FRUIT TREES AND OTHER PERENNIAL PLANTS. *Technical Communication No. 23.*

By S. C. Pearce. Commonwealth Bureau of Horticulture and Plantation Crops, Kent. 10s. or $1.40 (paper). x + 131 pp.; ill. 1953.

The first major statistical publication in the field of horticulture is generally recognized to be T. N. Hoblyn's *Field Experiments in Horticulture*, published in 1931. S. C. Pearce, long an associate and collaborator of Hoblyn at East Malling, has undertaken a complete revision and modernization of this important work in his *Field Experimentation with Fruit Trees and other Perennial Plants*. The outstanding characteristic of both Hoblyn's and Pearce's work is that the subject matter is organized and presented with the practical experimenter, rather than the mathematician, in mind. For this reason the average experimenter in biological fields, whose biometrical background may be somewhat sketchy, will be mildly shocked and certainly delighted to find that he has little difficulty in following the author's argument as to why, for example, randomized blocks provide one of the best experimental designs for field trials involving perennial plants. The publication does not purport to provide an elementary grounding in statistics, nor is it of the "cook-book" variety, i.e., with a worked-out example to accompany each design, and a detailed description of the computing method required. In the words of the author, "This he has preferred not to do. For one thing, it has been done before and done better than anything he could hope to achieve: for another, he believes that in computing results no less than in designing trials there is a long view of what it is about and a short view of what to do next, and he has tried to help those who want to take the long view." Four appendices are, however, added to the text, and these provide general methods for analyzing data for orthogonal designs, computing the analysis of variance, etc. Although no specific reference is made to field trials involving forest trees, there is an obvious similarity in the special problems involved. For this reason silviculturists and forest geneticists, as well as horticulturists, will find this publication a highly instructive valuable reference.

SCOTT S. PAULEY

SCIENCE AND FRUIT. *Commemorating the Jubilee of the Long Ashton Research Station, 1903–1953.*

Edited by T. Wallace and R. W. Marsh. University of Bristol, Bristol. $4.50. xiv + 308 pp. + 33 pl.; text ill. 1953.

This commemorative book consists of a series of articles written by present and former members of the staff. Scientific work of the Station from 1903 to 1953 in those fields to which Long Ashton has made substantial contributions is included. Principal among these are the art

and science of cider making, fruit growing, the pathology of fruit trees, and fruit processing in various phases. Other papers are concerned with a summary of researches in fields of more recent interest at the Long Ashton Station, such as micronutrients, plant growth substances, and the recently developed insecticides and fungicides. The book is liberally and well illustrated by half-tones and should be of special interest to American horticulturists and physiologists interested in an up-to-date review of the subjects under investigation at the Long Ashton Research Station.

SCOTT S. PAULEY

PLANT BREEDING FOR EVERYONE. *How to find and develop new plant varieties.*

By John Y. Beaty. Charles T. Branford Company, Boston. $2.75. 102 pp. + 14 pl.; text ill. 1954.

The author, a former associate of Luther Burbank, arouses and holds the reader's interest by frequently mentioning the large sums which have been paid for new varieties, by assuring him that a new plant variety is a contribution to mankind, and by pointing out the tremendous satisfaction which a breeder may achieve through perpetuating his own name by giving it to a new variety. But the instructions for attaining these admirable goals are decidedly elementary and frequently quite vague. Even the beginner would do better to consult Laurence's *Practical Plant Breeding*.

PAUL C. MANGELSDORF

INDIAN CORN IN OLD AMERICA.

By Paul Weatherwax. The MacMillan Company, New York. $7.50. x + 254 pp. + 3 pl.; text ill. 1954.

This is a fascinating book on a fascinating subject. It is primarily concerned (to use the author's own words) with an "endeavor to reconstruct a picture of the corn plant and the system of agriculture and household arts based on it as they existed in ancient America, with some consideration of the part that corn played in the everyday life, the thinking, and the artistic expression of the peoples of this hemisphere before Columbus came."

To accomplish this purpose the author has combed the narratives of the old Spanish and other European chronicles for references to maize and for illustrations of the plant and the uses to which it was put. In so doing he has discovered and mined a rich source of little-known material concerned with the history and native uses of America's principal food plant. The reports of these early writers are skilfully blended with the author's own extensive observations on modern practices among the Indians of both North and South America.

Thirteen of the 18 chapters are concerned with this, and make up the major part of the book. A list of these chapter headings provides a key to their scope: Introduction: The Problem; What to Call the Plant; Historical Sources; How the Spanish Found Corn; How Corn First Went to Europe; How the Old World Received Corn; Where Corn Grew in Old America; How Corn was Grown; Corn Used for Foods and Drinks; Unusual Uses of Corn; Conservation of the Cornlands; How the Indian Improved Corn; and Corn and the Culture of Old America.

It is perhaps too much to ask of a book of this size that it describe all of the ways in which maize was used by the American Indians and all of the customs and artistic expressions which grew up around its use. It is strange, however, that no mention is made of the picturesque Navajo sand paintings in which maize is so often depicted nor of the curious custom practiced in both North and South America of preparing maize for human consumption by anaerobic fermentation. This process, as it is practiced in Peru, has recently been described by Rick and Anderson, who have compared the odor of the product to "vases of flowers in which the water has not been changed often enough." The product was described in equally vivid language more than two centuries ago in Charlevoix's journal (1751).

On the whole, however, the historical treatment is comprehensive, objective, adequately documented, and is presented in a clear, readable style enlivened by pithy, sometimes pungent, comments which make the story interesting and absorbing. The author reveals previously unsuspected talents as an historian, and the history which he presents shows not only a highly developed cultural complex in pre-Columbian America with maize the dominating motif, but also the blindness of many of the early explorers who, in their greed for gold, overlooked the untold botanical wealth before their eyes.

The remaining 5 chapters deal with the biological aspects of the corn plant, especially those concerned with its origin. These chapters not only seem somewhat out of place in this particular setting, but they are by no means as excellent, either in style or content, as the remainder of the book. Readability is dimmed by the excessive use of undefined technical botanical terms. More serious is the omission of numerous important references in the extensive literature which has developed on this subject in the past two decades. Of the many stimulating and significant papers of Anderson, only one, a minor one, is included in the bibliography. Erwin's papers on sweet corn are mentioned, but more significant papers by Hendry and by Carter on the same subject are overlooked. Birket-Smith's conclusions regarding the South American origin of maize are not mentioned. There is no reference to Bonnett's excellent work on the developmental morphology of the inflorescences, to Longley's numerous contributions on the cytology of maize and its relatives, to Roger's extensive experiments on maize-teosinte hybrids, or to

Brieger's observations and experiments on pod corn and teosinte. Particularly conspicuous is the lack of any recognition of the progress which has been made in recent years in the classification of maize. No mention is made of the papers of Anderson and Cutler on this subject nor of the comprehensive taxonomic treatment of Mexican races of maize by Wellhausen et al. A reader unfamiliar with the subject would certainly gain the impression that little progress had been made in the last twenty years in biological research on maize.

On the question of the origin of maize and its evolution under domestication, the author differs sharply with my own conclusions, and in doing so makes numerous statements which conflict with the available evidence and in some cases with the evidence which he himself presents. This review is obviously not the place to consider all of these in detail, but a few examples may be pertinent. The author speaks repeatedly of the "equivocal" nature of pod corn and regards its variability as ruling it out as an ancestral form. He seems not to realize that practically all characteristics of the maize plant, including its monoecism, vary with both the environment and the genetic background, or that the ear, its most nearly unique feature, is as variable as the glumes of pod corn. Less monstrous forms of pod corn, such as half-tunicate, are ruled out as the primitive type because these characters are said to affect only the glumes and not the remainder of the plant. But the "half-tunicate" type illustrated in Fig. 51 shows that the author has been confused by an entirely different character, "semivestidos," recently described by Andres in Argentina and earlier by Bonvicini in Italy. Because Mangelsdorf and Reeves crossed maize with *Tripsacum* by removing the shucks and pruning the silks, the author concludes that a cross of these two genera could never have occurred in nature; yet he mentions or describes at least four conditions in maize—stunted plants, homozygous pod corn, flowering tillers, and his version of the hypothetical ancestor—in which the silks would be exposed for their entire length to pollen.

The book is profusely illustrated, largely with the author's own photographs and drawings. The illustrations, except the color plates, which lack fidelity, are generally excellent, and some of them are superb. They contribute substantially to making the book an interesting volume which should appeal both to laymen and professional biologists.

PAUL C. MANGELSDORF

DAHLIAS FOR EVERY GARDEN.

By Marian C. Walker; photographs by Roche. M. Barrows & Company, New York. $2.95. 128 pp. + 10 pl.; text ill. 1954.

AMARYLLIS—*and How to Grow Them.*

By Peggy Schulz. M. Barrows & Company, New York. $2.95. 128 pp. + 4 pl.; text ill. 1954.

DAYLILIES AND HOW TO GROW THEM.

By Ben Arthur Davis; regional chapters by Stanley E. Saxton, E. J. Kraus, and Homer T. Blackhurst. Tupper & Love, Atlanta. $3.50. xii + 150 pp. + 17 p.; text ill. 1954.

As in stamp collecting, the trend in gardening today is topical, with every gardener a potential specialist. It seems to me that there are both desirable and undesirable aspects to this trend: desirable, in the sense that success brings with it a sense of identity and of belonging to a group with common interests, a symptomatic and perhaps necessary step in an era when shifting values are characteristic; undesirable, in that gardening philosophy loses a certain earthiness which was the mark of the gardener who saw beauty in every flower. and who had a spaciousness of soul and outlook. These books reflect this narrowing trend, each being addressed to a relatively limited audience. The first two are run-of-the-mine books, complete enough to enable even an amateur to follow directions but lacking in distinction and character. That on daylilies is a more commendable volume, carrying the touch of authority and the sureness of competence. All, however, will appeal to garden-club members and to amateur exhibitors, although a comparable amount of money spent for seed and plant catalogues would provide an immensely greater amount of information and source of pleasure.

C. P. SWANSON

HISTORY OF THE ROSE.

By Roy E. Shepherd. The MacMillan Company, New York. $4.75. viii + 264 pp. + 12 pl. 1954.

Gardeners and flower-lovers whose interest goes beyond the growing of plants for decorative purposes will find this book an excellent source of information on the rose as regards historical reference, general taxonomic treatment, and the origin of cultivated forms. Greatest emphasis is given to the cultivated species and varieties, the author being particularly active in the Old Rose Preservation Committee of the American Rose Society. The book is well written and thoroughly documented, with illustrations of the major rose types, and Shepherd is to be complimented on his handling of a difficult taxonomic subject. Whether the classification which he uses—that proposed in 1869 by the Belgian botanist, Crépin—will be acceptable to the professional systematist is doubtful, but so far as the horticulturalist is concerned, it should suffice. However, the author has fallen into one serious difficulty. In considering cytotaxonomic data in arriving at ancestral forms of the rose, he assumes "that a northern decaploid species was the primitive rose from which all existing species have descended, because mutations which occur through the loss of chromosomes are presumed to be many times more numerous than those which occur through the acquisition of new ones." Since northern species have higher

chromosome numbers than those of a more southern range, it is also concluded that the center of origin was in the north, and that a loss of chromosomes occurred in groups of 7 so as to result in types better fitted for the more temperate southern regions. This line of reasoning is exactly opposite from that now accepted, of course, namely, that diploid forms are the ancestral stocks; and polyploids later derivatives. Fortunately, the author merely makes the above statements in regard to the general history of the rose, but does not use these misconceptions in his treatment of the broader taxonomic groups.

C. P. SWANSON

PLANT DISEASES. *The Yearbook of Agriculture, 1953. By Curtis May, Chairman, Yearbook Committee, and others. United States Department of Agriculture, Washington; [Superintendent of Documents, Washington.]* $2.50. xviii + 940 pp. + 32 pl.; text ill. 1953.

The 1953 *Yearbook of Agriculture*, on *Plant Diseases*, is a welcome and creditable complement to its predecessors which dealt with the other limitations to plant production—soils (1938), climate (1941), and insects (1952). Designed by law "to interest and instruct the farmers of the country," the Yearbooks of the U. S. Department of Agriculture go farther and provide much useful information for the industries, scientists, and educators that serve agriculture, as well as for the consuming population.

The present *Yearbook* first lays the groundwork in a series of chapters devoted to the economic significance of plant disease, the agents that cause or influence diseases, and the control of diseases by chemical, regulatory, and genetic means. The remainder and bulk of the *Yearbook* deals specifically with the nature and prevention of diseases of the various categories of crops: forage, cotton, grains, vegetables, sugar, tobacco, ornamentals, fruits and nuts, and a miscellaneous group; and it includes also a valuable section on post-harvest troubles of plant products.

Each of the many short chapters is designed to be self-contained, so that it may be distributed as a reprint. This fact, along with the wide diversity of authorship and the classification by crops, leads to a certain amount of duplication and a lack of continuity which are not to be regarded as faults, but rather as inevitable consequences of an editorial policy that, despite these drawbacks, best meets the requirements and responsibilities of the *Yearbook*. The result is not (nor was it intended to be) a logically continuous exposition of plant pathology, textbook-fashion, but is instead a series of authoritative discussions of leading current plant-disease problems, woven together in such a practical fashion as to make the many contributions readily accessible to those concerned.

The authors are well selected, and it is to the credit of the editor and the Department of Agriculture that authors not associated with the Department were chosen when these could make particularly useful contributions, as in the cases of Kunkel, Black, and McNew. In this respect, there is only one serious omission. Roughly one-third of the research serving agriculture in the United States is conducted by the many competent agricultural scientists in private industry, and these, and their work, have little representation in the *Yearbooks*.

The excellent, though economical, format of recent *Yearbooks* is continued in this one, combining attractiveness, ease of reading, and durability. A fine series of color plates illustrates the principal plant disease problems, and access to the contents is aided both by a detailed table of contents and a 32-page index. A glossary of technical terms is included to assist the nontechnical reader. There is a stimulating and understanding Foreword by Secretary Ezra T. Benson, who stresses the significance of plant diseases to our economy.

Since the *Yearbooks of Agriculture* are congressional documents, most of the copies printed are distributed by members of Congress, but 40,000 copies of this one are for sale by the Superintendent of Documents, while reprints of the various chapters are widely distributed upon request.

K. STARR CHESTER

GENERAL AND SYSTEMATIC ZOOLOGY

TRATTATO DI ZOOLOGIA.

By Umberto D'Ancona. Unione Tipografico-Editrice Torinese, Torino. L. 10,500 (paper). xxiv + 1102 pp.; ill. 1953.

This is a textbook of zoology that Professor D'Ancona has prepared for the 2-year course attended by students of the natural and biological sciences in Italian universities. The book has two parts. The first part (General Zoology) is subdivided into 5 long chapters: Subject Matter and Methods of Study in Zoology; Living Matter and its Functions; The Functional Organization of the Animal Body; Hereditary Fixity and Transformation of Organisms; and The Organism and the Environment. The second part (Systematic Zoology) has an introductory chapter on the principles of taxonomy, which is followed by a description of the variety of forms of the animal kingdom. The greater emphasis put by the author on the general part is indicated by the fact that 438 pages are devoted to this out of a total of 1,102 of text.

The material is well organized, clearly presented, and sufficiently illustrated. An unusual amount of very recent information is included in it. For once, we have a noteworthy example of a textbook that does not lag a decade behind current investigations. D'Ancona's

book is good evidence of the vitality shown by biological research and teaching in Italy in recent times. I wish that I might have had something of the sort at my disposal when I was a student there. Only one criticism of a general nature can be raised, and it is addressed to the publisher: a book of this size and number of pages would be more useful if divided into two volumes, which should also be bound.

A. A. BUZZATI-TRAVERSO

A CATALOGUE AND HISTORICAL ACCOUNT OF THE SLOANE SHELL COLLECTION. *Bull. Brit. Mus. (nat. Hist.), Hist., Vol. 1, No. 1.*

By Guy L. Wilkins. British Museum (Natural History), London. 16s. (paper). 47 pp. + 12 pl. 1953.

The year 1953 was the bicentenary of the death of Sir Hans Sloane, the founder of the British Museum. It seems appropriate therefore, at this time, to make an inquiry into what has become of the natural history collections assembled by Sir Hans during his long lifetime (he lived to be 93) and which upon his death became the nucleus of the museum's collection.

For many years it has been assumed that the shells in the Sloane collection could no longer be recognized, but the recent discovery of over 400 of Sir Hans' original specimens has stimulated the author to undertake this historical study of the Sloane shell collection.

The first work dealing with conchology to be published anywhere was the *Historia Conchyliorum* by Martin Lister, which appeared in instalments between 1685 and 1692. Lister was an associate of John Ray and Francis Willughby, and his book represents part of his contribution to a collective work on universal natural history projected by this triumvirate, but which, owing to the tragic death of Willughby, was never completed.

In those days the only collections in Great Britain with any pretense of completeness were those of James Petiver and Sir Hans Sloane himself. Practically all of Lister's illustrations were made from specimens in these two collections. Upon the death of Petiver his collection was purchased by Sir Hans, who incorporated it with his own, so that his catalog came as a result to include 5846 entries. It must not be assumed, however, that this figure represents the total number of items in the collection, for it was Sir Hans' practice to assign the same number to all samples of the same species, of which there might be a dozen or more. In such cases the records of the locality and the name of the original collector were meticulously preserved, so that even in the case of those specimens which have been irrevocably lost it is still generally possible to tell what they were.

The Sloane collection was derived from three sources: first, those specimens which Sir Hans himself collected; second, those from the Petiver collection; and third, those received from other collectors, scattered throughout the world. Among these may be mentioned John Bartram and Mark Catesby. The present work consists of a historical sketch of the Sloane collection, a catalog of about 250 specimens collected for specific reasons, with bibliographic references and comments, plates of manuscripts of Lister and Sloane, and illustrations of original specimens and original drawings. The problematical *Strombus sloanei*, which is just as much of a problem today as when Lister figured it, is not one of the latter although it is discussed in the text. There is a bibliography of 64 items, but no index.

JOSHUA L. BAILY, JR.

A REVISION OF THE GENUS *Tornos* MORRISON (LEPIDOPTERA, GEOMETRIDAE). *Bull. Amer. Mus. nat. Hist., Vol. 104, Art. 2.*

By Frederick H. Rindge. American Museum of Natural History, New York. $1.00 (paper). Pp. 1177–236; ill. 1954.

DIE LARVENFORMEN DER DIPTEREN. *Eine Ubersicht über die bisher bekannten Jugendstadien der zweiflügeligen Insekten. Teile 1–3.*

By Willi Hennig. Akademie Verlag, Berlin. (I) DM. 22.00; (II) DM. 49.00; (III) DM. 65. (paper). (I) iv + 185 pp. + 3 pl.; text ill. (II) vii + 458 pp. + 10 pl., text ill. (III) viii + 628 pp. + 21 pl.; text ill. 1948; 1950; 1952.

The hundred or so families of flies, encompassing perhaps 90,000 species, include many of the insects that are most annoying, pestiferous, and generally harmful to man, as well as notorious depredators of live stock, game, and crops. Of course, there are numerous flies that are strikingly beneficial from man's point of view, as well as many forms of unusual interest to biologists. And there is also *Drosophila*. That a large and hopelessly scattered literature has grown up about the immature stages of flies need awaken little surprise; but it is surprising that no notable synthesis of this knowledge has been made in the last thirty years, and that the relative inaccessibility of this material has been tolerated for so long. Hennig has at last removed this handicap for all who seek information about the external form, comparative morphology, and systematics of dipterous larvae and pupae, and his important and impressive work is a wonderfully useful compendium.

Hennig's goal is to bring together and consolidate what is so far known about the morphology of the immature stages of flies, to provide a taxonomic conspectus of fly larvae and pupae, illustrations of representative larval and pupal forms, and a guide to the original sources, as well as to point directly at the larger informational gaps that need filling. Lest new work suffer defects of much of the old, Hennig has also set out a commendable series of recommendations, standards,

and requirements for material and descriptions of immature stages. If generally met, these suggestions may be expected to improve greatly the usefulness of future studies.

Each of the three parts of this work deals primarily with one or more of the large taxonomic divisions of the Diptera, but the first section (regrettably now out of print) also includes Hennig's general comments and recommendations, as well as an essay on the theoretical aspects of zoological taxonomy. This essay is probably to be regarded as a prodromus to Hennig's *Grundzüge einer Theorie der phylogenetischen Systematik*; as such, it proves a difficult and rather unrewarding exercise. Despite its insistence on the rather obvious importance of a knowledge of immature stages to the systematist and evolutionist, this relatively short section seems fairly dispensable in so far as the rest of the work is concerned.

A clear review of the morphological characters of immature Diptera that are of known value to systematists comes after Hennig's account of the "theory of systematics." This discussion of anatomy is regrettably almost wholly concerned with integumentary and skeletal structures, but it does include a fine summary of the transformations that seem to have been involved in the evolution of the cyclorrhaphoid type of larval head (as in *Drosophila*) from that of a primitive larval type possessing a well-formed head capsule (like that of *Bibio*). Thereafter there is a brief summary of the relationships within the Diptera as illuminated by the study of immature forms. The conclusions reached are conservative, yet they provide much substance for thought and future work, especially in connection with the Nematocera.

The systematic treatment of the Diptera is partitioned in this way: Part 1, Nematocera Bibiomorpha (i.e., the Silvicolomorpha); Part 2, Nematocera Culicomorpha (in Hennig's treatment comprising Tipulomorpha plus Psychomorpha); Part 3, the entire suborder Brachycera. Aside from the introductory material of Part 1, and the location of both the index and bibliography for the entire work at the close of Part 3, the treatment is essentially the same within each portion of the monograph. Both the common and peculiar larval and pupal characters at each taxonomic level are discussed, but there is disappointingly little information given regarding the natural history of the immature forms. Wherever necessary, special morphology, chaetological systems, and so on, are fully described and illustrated. Thereafter dichotomizing keys, based on larval and pupal characters (and rarely those of the egg), are provided to successively lower groups wherever information permits. Under each genus for which the larva or pupa of an included form is known, Hennig employs a mode of recording information that provides a simple and excellent entry to the literature. Thus, for each species the general geographic distribution is recorded, and a coded listing is given of papers dealing with the larva and pupa, as well as a coded index of their illustrations (if any) of larval and pupal morphology. All these papers will no doubt prove informative upon consultation, for Hennig states that his bibliography (of approximately 2,400 listed titles) is a selected one that excludes papers of dubious value or negligible contribution. Without doubt Hennig has performed a useful service in sifting the papers in this way, for it will often save considerable effort on the part of those who use this work as a guide. Nevertheless, it is too bad that the rejected literature was not actually listed in the bibliography, but marked with an identifying symbol. Suppose that the publication date of a paper shows that it was available (at least in principle) to Hennig during the writing of this treatise. Does its absence from the bibliography necessarily stigmatize the work as inconsequential, or was it merely overlooked? Surely the missing contributions by Hall (1947) on blowflies, Patterson (1943) on *Drosophila*, and Simmons (1927) on *Piophila* are oversights rather than deliberate omissions.

These volumes will also prove valuable for their illustrations, which collectively form a fine atlas of the larvae and pupae of flies. The drawings are simply executed but effective ink sketches. In all, there are 635 text figures, most of which portray special aspects of larval and pupal anatomy. The 34 plates, encompassing 171 large figures, illustrate the general habitus of representative larvae and pupae.

This treatise, then, is a most notable and serviceable addition to the literature of entomology. Its use may be expected to stimulate markedly enquiries into the systematics, ecology, and biology of immature flies, and into the origin and evolution of the Diptera. As a handbook for identification, Hennig's volumes will assuredly displace Malloch's (1917) old and valued classic on the larval and pupal Diptera.

KENNETH W. COOPER

A FIELD GUIDE TO THE BIRDS OF BRITAIN AND EUROPE. *The Peterson Field Guide Series.*

By Roger Tory Peterson, Guy Mountfort, and P. A. D. Hollom; with an introduction by Julian Huxley. Houghton Mifflin Company, Boston. $5.00. xxxiii + 318 pp. + 62 pl.; text ill. 1954.

The lack of a convenient and reliable guide to the birds of Europe has long been deplored. There have been books on British birds, and others, mostly in French or German, on parts of the continent. Yet, until now, there has been no single volume which treated all of birds of all of Europe. This gap has now been excellently filled by Peterson and his coauthors. As well as making field identification easy, the volume contains a wealth of information valuable even to the professional. The amount of information compacted into this single volume is a marvel. The publisher has spared no expense

to provide an abundance of illustrations. In addition to the 64 plates, most of which are in color, there are numerous text figures, to total more than 1,100 individual illustrations, all by Peterson. Mountfort is principally responsible for the text and Hollom for the maps of the summer and winter distributions of the 367 breeding species. The work as a whole is the joint product of the three authors. It has set a record by having been published simultaneously in English, French, German, and Dutch. Further editions, in several additional languages like Swedish and Spanish, are in preparation or by now have been published. A few minor weaknesses or errors of the volume can be corrected easily in future editions, the worst of them being the adoption of an aberrant scientific nomenclature prepared by a committee of British amateurs. The new "European Peterson" promises to become the leading best-seller in the field of bird books, for it is going to be indispensable to all bird students and to all European travellers.

E. MAYR

CATALOGUE OF THE TYPE SPECIMENS OF RECENT MAMMALS IN THE AMERICAN MUSEUM OF NATURAL HISTORY. *Bull. Amer. Mus. nat. Hist., Vol. 102, Art. 3. By George G. Goodwin. American Museum of Natural History, New York.* $2.50 (paper). Pp. 207–412. 1953.

A total of 945 type specimens are on deposit at the American Museum of Natural History. They represent species of all orders except the Monotremata and Dermoptera, and many countries from both eastern and western Hemispheres. In the text each of the species or subspecies is listed with its original citation and its principal synonyms, followed by a brief description with measurements. The catalogue number is given, and comments are included regarding the condition of the specimen. This index should prove a useful reference for mammalian taxonomists.

BRYAN P. GLASS

MAMMALS OF THE MEXICAN STATE OF SAN LUIS POTOSÍ. *Louisiana State Universities Studies, Biological Science Series. Number One.*

By Walter W. Dalquest. Louisiana State University Press, Baton Rouge. $3.50 (paper). vi + 230 + iv pp.; ill. 1953.

The State of San Luis Potosí lies athwart the Sierra Madre Oriental and embraces the transition from low tropical forest on the east to high arid desert on the extreme west. Its fauna is correspondingly diverse, and hence interesting to one studying ecological distribution. Imagine a single political unit from which might be collected Brocket and Mule Deer, Jaguar and Bobcat, Kinkajou and Raccoon, Paca and Pocket Gopher, along with Spider Monkey, Four-toed Anteater, Vampire, Jack Rabbit, Canyon Bat, and Least Shrew. Such contrasts are multiplied among the 142 species and subspecies catalogued. The inclusion of a map of localities and a gazetteer does not, in my own opinion, compensate for omitting distribution maps from the species accounts. Otherwise the plan of execution follows the pattern of the University of Kansas publications, a pattern which has proven so satisfactory to most mammalogists.

BRYAN P. GLASS

ECONOMIC ZOOLOGY

EL GUANO Y LA PESCA DE ANCHOVETA.

By Robert Cushman Murphy. Compañia Administradora del Guano, Lima. Free upon request (paper); [a limited number of copies of an English version are available from the author at the American Museum of Natural History of New York]. 147 pp. 1954.

This report on guano and the anchovy fishery of the coast of Peru and northern Chile is based upon field work carried out by the author in December 1953 and January 1954 under the auspices of the Compañia Administradora del Guano. It consists of 39 pages of text by the author, followed by 104 pages of historical documentation, 1926–1954. This fascinating account, presented with all the insight and vigor of a distinguished natural scientist, is of interest to all biologists, especially to ecologists and others concerned with the vital problem of conserving renewable natural resources.

The author records that, due to enlightened management, the annual Peruvian guano crop has increased from 16,000 metric tons in 1909 to 255,000 tons in 1953. Future prospects are even brighter. The wealth has come from a natural balance between marine food supply and the guano-producing birds. The author warns that a rapidly growing Peruvian anchovy fishery for oil and fish-meal is likely to become detrimental both to the invaluable sea fowl and to such important food fishes as tuna, bonito, and skipjack.

B. H. WILLIER

CALIFORNIA FISHING PORTS. *Fish Bull. No. 96.*

By W. L. Scofield. State of California, Department of Fish and Game, San Pedro. Free upon request (paper). 159 + iv pp.; ill. 1954.

A DESCRIPTIVE STUDY OF CERTAIN TUNA-LIKE FISHES. *Fish Bull. No. 97.*

By H. C. Godsil. State of California, Department of Fish and Game, San Pedro. Free upon request (paper). 186 + iv pp.; ill. 1954.

These are the last of this series to be distributed with-

out charge; "budgetary considerations" require that henceforth they be paid for. This should be no great privation to those who have a real need for them, since they are well worth what they cost the taxpayers, at least from the viewpoint of the fishery biologist. Bulletin 96 is also of sociological and historical interest, for it reviews the history of each major port, often with some interesting old photographs. Bulletin 97 provides more morphometric and morphological detail than its title would suggest. The fishes described include various mackerel, bonito, and skipjack.

JOEL W. HEDGPETH

EFFECTS OF A ROCK SLIDE ON BABINE RIVER SALMON. *Bull. No. 101.*

By H. Godfrey, W. R. Hourston, J. W. Stokes, and F. C. Withler. The Fisheries Research Board of Canada, Ottawa. $1.00 (paper). x + 100 pp.; ill. 1954.

An account of the effects of a rock slide on the Babine River, British Columbia, especially on the sockeye runs of that stream, and the measures taken to alleviate the damage. The slide was in such an isolated region that 60 miles of road had to be built to get equipment to the scene.

ANIMAL GROWTH AND DEVELOPMENT

DIE ENTWICKLUNG UND MORPHOLOGIE DES CHONDROCRANIUMS VON *Myotis* KAUP.

By Hans Frick; preface by D. Starck. Georg Thieme Verlag, Stuttgart; [Intercontinental Medical Book Corporation, New York]. DM. 14.40 [$3.45] (paper). 102 pp.; ill. 1954.

This volume encompasses the results of some very painstaking and detailed research based on studies of both *Myotis myotis* and *M. cappaccinii*. The text is divided into chapters, of which the main ones deal with the descriptions and comparisons of the chondrocranium, the membrane bones, and the summary of the most important findings. The major part of the book is devoted to the chondrocranium, which is discussed and figured region by region, beginning with the ethmoid and ending with the visceral skeleton. The text is well illustrated with both line and half-tone drawings, excellently executed. It is evident that the research actually covered much more than just the development of the endochondral bones, for there is also much information on the placement of membrane bones, muscles, and nerves. The material used varied in size from 6 to 16 mm. in total (head) length, but some unmeasured specimens may have been smaller.

The part that embryologists will undoubtedly find most useful in making comparisons with embryos of other mammals is the summary, where the most important findings are spelled out by number for each region of the head.

BRYAN P. GLASS

ANIMAL MORPHOLOGY

A COMPARATIVE STUDY OF THE OSTEOLOGY AND MYOLOGY OF THE CRANIAL AND CERVICAL REGIONS OF THE SHREW, *Blarina brevicauda*, AND THE MOLE, *Scalopus aquaticus*. *Misc. Publ. Mus. Zool., Univ. Mich., No. 80.*

By George R. L. Gaughran. University of Michigan Press, Ann Arbor. $1.00 (paper). 82 pp. + 13 pl. 1954.

The comparisons made in this anatomical dissertation are limited to the cranium, visceral skeleton, cervical vertebrae, myomeric and branchiomeric musculature, and sense organs. In general, the differences encountered between these forms are those that would be expected between fossorial and ambulatory animals. *Blarina* has structures adapted for activity and flexibility, *Scalopus* for strength and robustness at the expense of mobility. The eye in both is highly degenerate, although the former probably does possess limited vision. Probably the 23 plates of drawings are the part of this volume that will attract widest use, for they are excellent and cover all aspects of the study.

BRYAN P. GLASS

MORRIS' HUMAN ANATOMY. *A Complete Systematic Treatise. Eleventh Edition.*

Edited by J. Parsons Schaeffer. Contributors: Leslie B. Arey, Raymond F. Blount, Eliot R. Clark, Harold Cummins, J. C. B. Grant, Frederick Gudernatsch, Ernest Lachman, Olof Larsell, J. E. Markee, Bradley M. Patten, Richard E. Scammon, J. Parsons Schaeffer, C. G. Smith, Robert J. Terry, and Mildred Trotter. The Blakiston Company, New York and Toronto. $16.00. 1718 pp. + 8 pl.; text ill. 1953.

The present edition of this well known work commendably continues the standards that have made it one of the leading textbooks of gross anatomy. Its general aspect is largely the same as previously, but seven new contributors have reworked 5 of the 13 major sections. A number of new roentgenograms of the stomach and intestines, diagrams of the bronchopulmonary segments of the lung, and numerous new illustrations of the urogenital system reflect current trends in clinical emphasis. The format has been modernized, with the small type in double columns and the entire book slightly smaller, although the number of pages and illustrations has been increased. The book should continue to enjoy a high position in its field.

F. N. LOW

A HANDBOOK FOR DISSECTORS. *Fourth Edition.*

By J. C. Boileau Grant and H. A. Cates. The Williams & Wilkins Company, Baltimore. $3.00. xiv + 425 pp.; ill. 1953.

This sparsely illustrated (26 figs.) dissecting manual specifies procedures and describes the chief structures encountered in a regional dissection of the human body. A short introductory chapter is devoted to method. There follows one chapter each on the 5 major regions of the body (upper limb; abdomen; lower limb; thorax; head and neck). There is a final chapter on the brain. An index is included. Subject to the limitations of dissecting manuals in general, this volume should be adequate for its purpose.

F. N. LOW

GYNAECOLOGICAL AND OBSTETRICAL ANATOMY AND FUNCTIONAL HISTOLOGY. *Third Edition.*

By C. F. V. Smout and F. Jacoby. The Williams & Wilkins Company, Baltimore. $7.00. viii + 336 pp. + 2 pl.; text ill. 1953.

This little book by two English anatomists, as can be judged by its title and its relatively few pages, presents a great deal of information in rather concise form. Those who wish to quickly refresh their knowledge on any point concerning female pelvic anatomy or function will find it quite useful. In other words, the book will serve chiefly as a pre-examination refresher for medical students and gynecologists and obstetricians about to take their specialty board examinations. As such, it is excellent, for considerable effort has obviously been made to keep it readable, well illustrated, and up to date.

GEORGE W. CORNER, JR.

FUNCTIONAL NEUROANATOMY. *Second Edition, revised and augmented.*

By Wendell J. S. Krieg; with illustrations and decorations by the author. The Blakiston Company, New York and Toronto. $9.00. xviii + 660 pp.; ill. 1953.

Eleven years have passed since this radically different treatment of neuroanatomy first appeared (*Q.R.B.*, 17: 372. 1942). Both text and illustrations have been increased, with emphasis on the latter. There are new drawings on the thalamus, the human cerebral cortex, the medullary centers of cerebrum and cerebellum, the internal anatomy of the temporal bone, and the gross anatomy of the brain.

As in the first edition, the approach commits itself to the proposition that the development of a three-dimensional concept of the brain is a prime difficulty in neuroanatomy and that the illustrations of a text ought to solve this problem. It is true that difficulties of three-dimensional visualization are common among students. Yet, after the initial rash of complaints is over, average students are able to think quite expertly in three dimensions with the aid of ordinary slides and illustrations of comparably thin sections. The "slice reconstruction" drawings used so extensively by Krieg to promote three-dimensional thinking are quite difficult to interpret. Adjustments for depth (not always clearly represented) must be made within a single reconstruction, and it is almost impossible to put a series of these drawings together in one's mind to form a satisfactory three-dimensional concept of the whole mass. This difficulty is well exemplified by the eyeball-flattening series of double-page drawings on pp. 552–643. Elsewhere the illustrative style varies from classic line drawings to the ill chosen white-on-black series of brain dissections (figs. 19F–19P), which add nothing to the usual black-on-white representations and are downright difficult to look at.

The organization of the text is no less original than the choice of illustrations. Beginning with two introductory chapters covering architectonics, methods and development, the third chapter concerns reflex mechanisms of the spinal cord, and the fourth introduces the brain. Descriptions of functional systems largely located within the brain-stem follow in subsequent chapters. But, for the most part, the text roams about at large, limited chiefly by structural and functional chapter headings. A chapter entitled Non-Neural Inclusions with the Nervous System is sandwiched, for no apparent reason, between one on the cerebral cortex and another on the cerebellum. Reference to the illustrations is, in accordance with the preface, more extensive than usual, but the introductory and interpretative passages are less coherent. The author certainly draws on a wealth of material and ideas, but time-honored systematic classifications are about half honored. They are frequently mixed with new ones, drawn from reliable enough sources and individually satisfying, but new ones that tend to fight with the older ones and with each other. The interpretive excursions of this text may well be stimulating to the beginning student, but they are not likely to promote a coherent concept of the nervous system as a whole. The most successful presentations of neuroanatomy are those which succeed in bringing eventual order out of the chaos of complexity which at first plagues the student. There is little about this text to encourage its use for such purpose.

It is difficult to write a critical evaluation of a highly original treatment of any subject. One is caught up between respect and affection for the monumental works of established usage, on the one hand, and the need for new and vigorous approaches, on the other. Any writer with the courage to break with tradition, as in this text, must necessarily identify himself with the avant garde, with its folly and with its virtue. A work of exceptional merit is required to accomplish a successful departure from established custom. It is my considered opinion that the praiseworthy purpose of

this work has not been accomplished; but its originality will certainly influence attitude and approach in its field. Perhaps that is enough.

F. N. Low

APPLIED ANATOMY AND KINESIOLOGY. *The Mechanism of Muscular Movement. Seventh Edition, Revised.* *By Wilbur Pardon Bowen, revised by Henry A. Stone. Lea & Febiger, Philadelphia.* $5.50. 462 pp. 1953.

This seventh edition of Bowen's *Applied Anatomy and Kinesiology* (6th ed., *Q. R. B.*, 26: 85. 1951) has been revised by Henry A. Stone "to satisfy the need for a more nearly complete teaching aid." It is a well-written, well-organized book, with excellent illustrations. It is interesting and easy to read, and includes many bits of related information and interpretations that make the detailed anatomical information take on a practical significance.

Part I includes discussions of the mechanical principles involved in joint and muscle action, the center of gravity and planes of the body, skeletal anatomy, muscle structure and action, the anatomy and physiology of the nervous system as related to control of muscles, voluntary muscle action, team work among muscles, and the chemistry of muscular action.

In Parts II, III, and IV the muscles of the upper extremity, lower extremity, and trunk are discussed from the standpoint of their origin, insertion, innervation, structure, and action. Especially helpful are the details included under the topics of structure and action.

In Part V are descriptions of muscle function in the erect posture; in walking, running, jumping; in games and sports; and in occupation and the activities of everyday living. The appendix consists of drawings (from Gerrish) showing the area of muscular attachments on the bones of the upper extremity and scapula, and the lower extremity and pelvis.

For the most part the book consists of material derived directly from other writers who are recognized authorities in their respective fields. From a wealth of information the author has successfully selected and compiled the information necessary for a good book for the student of kinesiology.

My chief criticism of this book is a fault I find in many books on kinesiology. Although the science of kinesiology is supposedly applied both to the improvement of skill in activities, and to the improvement of the individual from the standpoint of better body mechanics, the stress is on the former. Detailed analysis of the muscle action in sports is stressed, detailed muscle analysis of the individual is omitted. The two-fold purpose of kinesiology will not be accomplished unless tests for voluntary muscle action are incorporated into a course of study.

HENRY O. KENDALL.

TEXTBOOK OF HISTOLOGY. *Second Edition.* *By Jose F. Nonidez and William F. Windle. McGraw Hill Book Company, New York, Toronto and London.* $9.50. xvi + 528 pp.; ill. 1953.

Of textbooks of histology for medical students, the one by Arthur Ham has seemed superior to me. Therefore, in evaluating the present volume, I was inclined to compare the two. Happily, this one stands up well in competition.

The book has the virtue of being distilled and concise, including, however, all the details necessary for the serious beginning student of histology. Windle, in his Preface, justifies brevity by pointing out that the changing requirements of a modern medical curriculum have compressed the time allotted to histology. Modifications in teaching methods have been needed. With this in mind an appendix on Visual Aids has been included. It lists and briefly describes motion pictures that can augment lectures or laboratory exercises. The extensive use of motion pictures seems a worthwhile modernization of a course in histology. It appears customary for textbooks of histology to give considerable space to the gross anatomy, embryology, and physiology, integrating and correlating these subjects with histology. The present volume covers these subjects in an abbreviated form. The relation of structure to function is treated adequately. However, the treatment of embryology may be too sketchy.

In the chapter on bone marrow an orderly chart on blood cell precursors and associated with it a table of common synonyms for each cell would be valuable. (The student of clinical hematology suffers from a long-standing confusion in terminology, and clarification when first learning about cells of the blood is needed.)

Helpful tables are included, and the illustrations in general are excellent. Scattered throughout are aphorisms that should stimulate the students' enthusiasm for the material, such as: "muscle is responsible for all outward manifestations of life"; or in the chapter on excretory organs: "it is taught in botany that beans are kidney-shaped. Anatomists declare that kidneys are bean-shaped. One should be less concerned about their shape than how they work."

RALPH M. KNISELEY

HISTOLOGY. *Edited by Roy O. Greep; with thirteen contributors. The Blakiston Company, New York and Toronto.* $15.00. xii + 954 pp.; ill. 1954.

The lineage of this book is a long one, having had its origin in the European text of Stöhr. It has passed through the American editions of Lewis and Stöhr, Bremer, and Bremer and Weatherford. But the Preface suggests that it is really new, since less than half of the illustrations and almost none of the text of the previous edition have been retained. It is organized along conven-

tional lines: each chapter presents its material with adequate illustrations and closes with a bibliography. Each contributor, the roster of whom is most impressive, has done an adequate and acceptable job where, in many cases, an outstanding one might have been expected. The net result is a textbook that is acceptable and worthy of recommendation for routine use, but one that is quite undistinguished in its field.

F. N. Low

LABORATORY DIRECTIONS IN HISTOLOGY.

By E. D. Goldsmith and Gerrit Bevelander. Burgess Publishing Company, Minneapolis. $2.25 (paper). iii + 55 pp. 1953.

This extremely elementary set of laboratory directions is divided into General Histology (45 pp.) and Dental Histology (8 pp.). The very brief descriptions and instructions specify the slide to be used (with number blank for insertion) and the drawings to be made. The back of each page is blank, presumably for the drawings. Its usefulness is very limited, even at an elementary level of instruction.

F. N. Low

HISTOPATHOLOGIC TECHNIC AND PRACTICAL HISTOCHEMISTRY.

By R. D. Lillie. The Blakiston Company, New York and Toronto. $7.50. x + 502 pp. 1954.

This is a revised edition of Lillie's *Histopathologic Technic*, published in 1947. Here are presented selected examples of some of the newer methods developed within recent years. It is apparent that the author has spent a considerable amount of time in developing many of these methods so that they will be workable under ordinary laboratory conditions. There are fairly extensive descriptions of the techniques used for microscopy and its equipment, fixation, sectioning, stains and staining, mounting procedures, nuclei and nucleic acids, amino acids, end groups, etc., cytoplasmic granules, enzymes, endogenous pigments, exogenous pigments and minerals, various cell products, fats and lipoids, connective tissue fibers, bacteria, protozoa and other parasites, glia and nerve cells and fibers, hard tissues and decalcification. It is a very adequately indexed manual and should be of value to cytochemists and histologists.

David B. Tyler

ANIMAL PHYSIOLOGY

HUMAN PHYSIOLOGY.

By W. B. Youmans. The Macmillan Company, New York. $6.00. xiv + 480 pp.; ill. 1954.

This is not a new edition of the same author's *Basic Medical Physiology* but an entirely new book from a different publisher, and written primarily for the student with little or no background in science. To make up for the student's deficiencies the first section of the book deals with a sketchy presentation of chemistry, physics, and gross and histologic anatomy. This is followed by an engrossing account of the functions of the organ systems of the human body, with infrequent references to analogous processes in the lower forms of life. Discussions of the functional aspects of nutrition, metabolism, and nervous and endocrine control comprise the concluding chapters of the book.

The author states in the Preface that he has intended to provide "a standard body of specific factual information." The chapters are well written, informative, and brief enough to command the reader's constant attention. The glossary in the appendix might well be called a junior medical dictionary. The author has wisely made the definitions as simple as possible; to do so he has had to sacrifice the *full* meaning of the term on a few occasions, but in almost every instance the definition is adequate for the purpose for which it was intended.

This attractive, well-indexed book by the Professor of Physiology at the University of Wisconsin should prove a worthy addition to the growing list of "small" physiology textbooks which already includes, among others, such names as Amberson and Smith, Best and Taylor, Carlson and Johnson, Zoethout and Tuttle, and, as of recent date, Langley and Cheraskin.

A. Kurt Weiss

TEXTBOOK OF PHYSIOLOGY AND BIOCHEMISTRY. *Second Edition.*

By George H. Bell, J. Norman Davidson, and Harold Scarborough; foreword by Robert C. Garry. E. & S. Livingstone, Edinburgh and London; [The Williams & Wilkins Company, Baltimore]. $9.00. xii + 1002 pp. + 110 pl.; text ill. 1953.

The second edition, three years after the original appearance of this textbook (*Q. R. B.*, 27: 109. 1952) still represents an introduction at most to the study of physiology and biochemistry. The original aim was to treat the two subjects as one and to point out wherever possible their relevance to clinical problems, the authors being respectively a physiologist, a biochemist, and a clinician. The textbook, which is intended primarily for medical students as well as those in dentistry and veterinary science, places its main emphasis on human physiology and supplements this only where necessary by descriptions of animal experiments. While the attempt to integrate physiology and biochemistry, together with some clinical aspects, into a single textbook is admirable, the authors have had to pay the serious price of an incomplete and inadequate coverage of all the phases involved. The chapters on carbohy-

drates, lipids, proteins, nucleic acids and nucleoproteins, enzymes, and biochemical mechanisms are incomplete and deficient, especially for the medical student. The book remains essentially an introductory textbook in human physiology with some correlation to clinical matters and an even slighter treatment of biochemistry.

ALVIN NASON

PRAKTISCHE ARBEITSPHYSIOLOGIE.

By Gunther Lehmann. Georg Thieme Verlag, Stuttgart. DM. 33.00. 354 pp.; ill. 1953.

Written by the director of the Max-Planck-Institut für Arbeitsphysiologie, this book presents a new and healthy approach to the problem of applying research data obtained in the laboratory to practical situations as they are encountered in the factory, coal mines, building projects, i.e., wherever work is performed. The premise of the arguments presented is the belief that the task and aim of "Arbeitsphysiologie" are the correlation of tools and performance with the biological make-up of man, so as to reduce unnecessary stresses and fatigue, and to achieve working conditions which favor an increased production output. Basic physiology is presented only to introduce practical applications; psychological needs are taken into consideration and discussed.

Chapters 2 to 5 deal with the classical aspects of the physiology of exercise. Chapter 6 concerns itself with engineering problems as they apply to human needs. Here one feels that a more positive approach might ultimately have proven to be more helpful. The remaining six chapters deal with the effects of the environment (temperature, pressure, food and water supply, vision, noise, vibration, wages, working conditions, working hours) on the productivity of man and his personal energy output. Here, frequent references to German labor legislation may preclude a wide interest in brief sections of this book. On the whole, however, this work represents a scholarly approach to the problems of human engineering and may be recommended to physicians, supervisors, designers, and administrators in industry as well as to the biological scientist who takes interest in applied physiology.

A. KURT WEISS

BASIC PHYSIOLOGY OF EXERCISE.

By Ferd John Lipovetz. Burgess Publishing Company, Minneapolis. $5.00. xii + 170 pp.; ill. 1954.

Unfortunately, there is little in this book to recommend it. Its title is a misnomer, since less than half of its content deals with basic physiology, the rest taking up such topics as physical fitness, physical education, and athletics. While the author must take the blame for the many errors both of commission and omission, one also wonders about the publishing house. Burgess Publishing Company has in the past been responsible for substantial additions to the scientific literature. In this instance carelessness in production has resulted in a book which is as full of printing errors as it is of factual ones. The physical education student has usually more than enough difficulty with the subject matter of physiology. Why then confuse him still further by statements such as the following: "Based upon the law that approximate stimulation of an organ . . . will produce the best results, heart and lungs . . . should receive much stimulation by means of physical exercise"? A good proof-reader, changing the word "approximate" to "appropriate" and correcting many similar errors, might have done this book some good.

However, *no* amount of proofreading could correct the misstatements of fact in which this book abounds. The following excerpt is taken from page 2: "The conversion of carbohydrates to sugar to glycogen and reverse is performed by *insulin*" (sic). The physiological concepts advanced by the author have in many instances been discarded years ago. An example of this is found in the chapter on the Chemistry of Muscle and the Chemical Changes of Contraction, wherein myosin is mentioned only once and is dismissed with the statement that the exact function of this compound is still in the experimental stage. Caveat emptor.

A. KURT WEISS

VITAMINS AND HORMONES. *Advances in Research and Applications. Volume XI.*

Edited by Robert S. Harris, G. F. Marrian, and Kenneth V. Thimann. Academic Press, New York. $8.50. x + 356 pp.; ill. 1953.

Volume XI of *Vitamins and Hormones* contains a number of interesting and informative reviews. Two of them are concerned with the function of ascorbic acid, the first by L. W. Matson on Ascorbic Acid Function in Plants, and the second by A. P. Meiklejohn on The Physiology and Bio-Chemistry of Ascorbic Acid. Three papers deal primarily with various functions of steroids or related problems. The first is a review of the biochemistry and physiology of Vitamin D; the second is a discussion of the relation of pantothenic acid to adrenalcortical function, and the third deals with chemical problems in the synthesis of cortisone and related 11-ketosteroids. An interesting methodological paper on the cytochemical localization of ketosteroids, by Dean and Seligman, discusses in some detail various artifactual influences which must be taken into consideration in assaying tissues microcolorimetrically for compounds containing carbonyl groups, e.g., particularly ketosteroids. Two other papers, by Zubiran and Gómez-Mont, and J. Gross and R. Pitt-Rivers, deal respectively with endocrine disturbances and chronic human mal-

nutrition, and with recent biochemical knowledge of the thyroid gland.

The two papers of greatest interest to me were those dealing with the histological localization of ketosteroids and the physiology and biochemistry of ascorbic acid. The former paper is of interest primarily because of its discussion of the interference by plasmal in the determination of ketosteroids (by the Feulgen technique or by the use of ketonic reagents such as substituted phenylhydrazine). Plasmal has recently been demonstrated in our laboratory to be a necessary cofactor for the luminescence of luminous bacterial extracts and appears to be involved in oxygen activation and perhaps in peroxide binding. The burden of the paper by Dean and Seligman is that one must exercise considerable care and caution in the use of histological stains for the localization of ketosteroids, since obviously any other biological constituent which also would react with the dye would give similar results. One such class of compounds is that of the long-chain fatty aliphatic aldehydes. A brief discussion is also given of other histochemical and optical methods for identifying steroids, notably fluorescence, birefringence, ultraviolet absorption, and selective solution in organic solvents.

Despite the methodological difficulties which have faced histochemists in this field, the final section of this paper presents a review of well-documented occurrences of ketonic steroidal substances in hormone-producing tissues. The concluding sentences of this review summarize the status of the particular problem. "Empirically there is a direct correlation between carbonyl lipid and secretory activity, both in physiologically altered and in abnormal glands. The significance of this correlation will be understood only when the chemical identity of the stainable materials is more fully known."

The review by A. P. Meiklejohn of ascorbic acid biochemistry is of interest, aside from its excellent historical review and modest presentation, because it pinpoints so well one of the basic afflictions of the competitive business that science is now becoming. Some of these remarks are so well taken that it would seem proper to quote them here. "Today, too frequently, research is a highly competitive business. The result is that experiments are often hurriedly conducted—sometimes without adequate control of the method employed—and as quickly reported. Though the author's conclusion may be intended to be no more than tentative, they are not always taken as such by hurried reviewers, who may subsequently report them as established facts, particularly if they happen to fit conveniently into some preconceived hypothesis. Unfortunately, so many people are now pursuing preconceived hypotheses that sometimes nothing but confusion remains. This is particularly hard on the young research worker looking for the path of truth to follow in his investigations. He is faced with the vast literature of contradictory statements, the merits or demerits of which are not easy to discover. He may well decide that the whole subject is too difficult, and further scientific enquiry therefore profitless. Alternatively, he may embrace the deductive speculations of some previous writer, and design for himself an experiment with the object of proving them true. It needs only a little imagination to see that these trends may well spell the beginning of the end of progress in medical science. The possibility of a new dark age, dressed up in all the learned jargon of science and founded on deductive interpretations of the previous literature is no mere Wellsian nightmare.

"Fortunately there are ways of avoiding this danger. For instance, in teaching students we do well to direct their thoughts to the frontiers of medical science, without too much emphasis on the well-worn paths where we think we know the way. In order that they may see where the frontiers lie, it is necessary to show them the weaknesses in existing knowledge and evidence; this can only be done by vigorous criticism."

In my opinion, these and other papers make this a volume that upholds the high standards of the earlier volumes of this series.

BERNARD L. STREHLER

MÉCANISME PHYSIOLOGIQUE DE LA SÉCRÉTION LACTÉE. *Colloques Internationaux, XXXII. Strasbourg, Août 1950.*

Centre National de la Recherche Scientifique, Paris. 1,200 fr. (paper). 181 pp. + 56 pl.; text ill. 1951.

An international colloquium concerning the physiological mechanisms in milk secretion was held in Strasbourg, France, in August, 1950. Publication of the 27 papers presented there makes available a concise summary of the progress made during recent years in this important field. It was appropriate that this conference be held at Strasbourg, at the institution where P. Bouin did his pioneer work on the hormones which influence the growth of the mammary gland and in whose laboratory Stricker and Grüter first showed the presence of the lactogenic hormone in the anterior pituitary.

It was also interesting that Pierre Stricker of Mulhouse was present to review the early work on the lactogenic hormone. Other French endocrinologists who presented papers included Klein, Racadot, Simonnet, Verne, Mayer, Collin, and Letard.

The United Kingdom was represented by John Hammond, whose research in animal physiology at the University of Cambridge has received world-wide recognition. His studies on the normal growth of the cow's udder stimulated much of the early work in this field. The experimental stimulation of udder growth and lactation was discussed. Folley French and Macaulay represented the National Institute for Research in

Dairying. Margaret Macaulay's presentation of the factors involved in the ejection of milk was outstanding. Richardson, of University College, London, whose fine preparations of the udder showing the location and structure of the myoepithelial cells responsible for the ejection of milk, laid the foundation for the physiological work.

American representatives included Nelson and Lyons. Lyons reviewed his recent work on the role of the sex hormones, estrogen and progesterone, in stimulating growth of the lobulo-alveolar system of the rat, whereas Nelson reviewed work which he believes indicates a role of estrogen in suppressing lactation.

Such conferences as this are of great value not only to the participants but also because the published report brings together for students the recent advances being made, in the present instance in the knowledge of the physiology of mammary gland growth and the lactation process.

CHARLES W. TURNER

L'EXPLORATION FONCTIONNELLE DE LA CORTICO-SURRÉNALE PAR LES STÉROÏDES.

By Jean Schwartz. Masson & Cie, Paris. 960 fr. (paper). ii + 161 + ii pp.; ill. 1953.

This little monograph is an admirably concise analytical introduction to present views regarding the problems of cortico-steroid functions and the techniques being developed for their study. It contains a survey of the steroids which have been isolated from the adrenals and of the essential concepts of adrenal physiology, followed by chapters on the biological and technical problems associated with the study of the urinary 17-ketosteroids and the urinary corticoids; functional tests of the adrenal, steroid chromatography and absorption spectra, and a final chapter indicating certain points which have already emerged regarding steroid metabolism. The volume contains a bibliography of 368 references, a preface by Julien Warther, and an avant-propos by Gregory Pincus, who concludes, "En plus des maladies à proprement parler endocreniennes, nombre d'affections ont un retentissement stéroide dont l'étude systematique s'impose. C'est pourquoi la monographie de Jean Schwartz vient en temps opportun."

EVELYN HOWARD

CIBA FOUNDATION COLLOQUIA ON ENDOCRINOLOGY. *Volume VII. Synthesis and Metabolism of Adrenocortical Steroids.*

Consulting Editor for this volume, W. Klyne; editors for the Ciba Foundation, G. E. Wolstenholme and Margaret P. Cameron. Little, Brown & Company, Boston. $6.75. xviii + 297 pp. + 1 map.; ill. 1953.

In a foreword to this volume, G. F. Marrian says that "steroid research lost its esoteric character in 1949 almost overnight following the announcement from the Mayo clinic of the dramatic effects of the administration of cortisone on the symptoms of rheumatoid arthritis. Steroid chemistry has, in the course of a few years, grown to become one of the major branches of organic chemistry. Partly in consequence of the availability of solvent partition chromatographic methods, progress in the important tasks of isolating and identifying steroid hormone metabolites in urine and blood, and in developing methods for their quantitative determination has been enormously accelerated. In recent years we have begun to obtain some insight into the chemical mechanism involved in the biogenesis of the steroid hormones. The task for the immediate future is to discover more about the chemical mechanisms involved when the steroid hormones produce their characteristic physiological actions on their target organs." The symposium consists of 20 papers, with records of discussion, and presents an interesting and informative collective report of the status of research in the synthesis and metabolism of adrenocortical steroids.

EVELYN HOWARD

TECHNIQUES BIOLOGIQUES EN ENDOCRINOLOGIE EXPÉRIMENTALE CHEZ LE RAT.

By Guy Poumeau-Delille; preface by R. Courrier. Masson et Cie., Paris. 1,600 fr. (paper). 206 pp.; ill. 1953.

Adequate descriptions, with line drawings, of most of the endocrine "-ectomies," including removal of the kidney; together with rather a hodge-podge of physiological observations of a generally superficial nature.

H. R. CATCHPOLE

DIE WELT DER SINNE. *Eine gemeinverständliche Einführung in die Sinnesphysiologie. 2nd Edition. Verständliche Wissenschaft, 19ter Band.*

By W. v. Buddenbrock. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM. 7.80. viii + 148 pp.; ill. 1953.

This little volume, one of a series popularizing science edited by Karl von Frisch, deals with the evolution, use, physiology, and anatomy of the sense organs of invertebrates as well as vertebrates. No doubt every zoologist reading this book will find some material new to him. The lack of index and references, however, limits its use.

HERBERT W. LEVI

BASIC ODOR RESEARCH CORRELATION. *Ann. N. Y. Acad. Sci., Vol. 58, Art. 2.*

Edited by Roy Waldo Miner; consulting editor, Amos Turk; 40 contributors. New York Academy of Sciences, New York. $3.50 (paper). Pp. 13–260; ill. 1953.

This monograph is the result of a conference held by the New York Academy of Sciences in cooperation with the American Society of Heating and Ventilating Engineers. Twenty-five papers are included, approximately equally divided between those discussing industrial odor problems and others in which fundamental physiological studies are presented. Since it is generally agreed that the chemical senses are poorly understood because of difficulties in testing methods, it is appropriate that nearly one-third of the papers are primarily concerned with technical methods of measuring or identifying odors. The inclusion of two studies on insect chemoreception, discussed with reference to fundamental olfactory mechanisms, provides an example of the commendable variety of viewpoints represented. For the specialist who wishes to become acquainted with the interests of others whose work touches upon this area of sensory physiology, this monograph is currently unexcelled.

EDWARD S. HODGSON

ANIMAL NUTRITION

DIE ERNÄHRUNG. *Physiologie, Pathologie und Therapie.*

Edited by Konrad Lang and Rudolf Schoen; contributors: R. F. A. Dean, W. Diemair, W. H. Fahndrich, R. Jürgens, F. Koller, J. Kühnau, K. Lang, E. Lehnartz, K. Mellinghoff, A. Nitschke, R. Schoen, and A. Vannotti. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM. 58.00. viii + 628 pp.; ill. 1952.

This cooperative venture embraces in 14 chapters a survey of nutritional physiology, pathology, and therapy. The book opens with a chapter on (1) the structural chemistry of basic food constituents and another on (2) energy metabolism and nutrient requirements. Succeeding chapters deal with (3) the preparation of foods, (4) malnutrition, overnutrition, and undernutrition, (5) dietetics (primarily from a therapeutic clinical point of view), (6) the physiology and pathology of infant nutrition, and (7) the regulation of national nutrition. This last chapter deals with the problems of rationing in England during World War II.

The last third of the book is devoted almost exclusively to the vitamins and associated topics. A good survey chapter covers the field up to and including 1951. Separate chapters are devoted to Vitamin A, Vitamin E, the B complex, Vitamin C, and Vitamin K. Particular emphasis is placed upon the clinical and therapeutic aspects of vitamin function. In one of the final chapters, entitled Rickets, Tetany and Osteomalacia, the role of Vitamin D is discussed.

Die Ernährung is a thorough, intelligibly written book which is enhanced by exceptionally clear type. Despite its many authors, the book contains only a minimum of repetition. It is adequately illustrated, and many useful tables are to be found in several of the chapters. It has most of the qualities of a good textbook. As a reference work, it suffers from a noticeable lack of uniformity, particularly in the form and completeness of the bibliographies which follow the chapters. While some authors have provided detailed documentation (e.g., more than 400 references in the chapter on Vitamin A), other contributors completely omit any bibliography (e.g., the chapter on the B vitamins).

As a whole, *Die Ernährung* will be of value primarily to those who are not at home with the English language. Several authoritative British and American texts cover similar material.

CLAUDE F. BAXTER

BIOPHYSICS AND GENERAL PHYSIOLOGY

RADIATION BIOLOGY. *Volume I: High Energy Radiation. Parts 1 and 2.*

Edited by Alexander Hollaender; with the cooperation of Austin M. Brues, Herman J. Muller, Berwind P. Kaufmann, and Lauriston S. Taylor. Prepared under the Auspices of the Committee on Radiation Biology, Division of Biology and Agriculture, National Research Council, National Academy of Sciences, Washington. McGraw-Hill Book Company, New York, Toronto, and London. $17.50 (two parts). (I) x + 626 pp.; ill. (II) Pp. 627–1266; ill. 1954.

This first of three volumes to be published on the subject of radiation biology deals largely with high-energy radiation. The succeeding volumes will cover the fields of ultraviolet and visible light effects on living tissue.

Part I of this generally excellent volume is chiefly concerned with basic principles and the more abstract results of studies in radiation biology. In so far as present knowledge can deal with some of the subjects discussed, the treatment in this part of the volume is thorough, concise, and reasonably readable. The first 5 chapters deal with the physical, chemical, and biochemical aspects of the interaction of high-energy radiation with matter. The introductory chapter by U. Fano outlines very readably the basic principles of radiological physics. This is followed by a chapter on the problems in the measurement of ionizing radiation, with a specific orientation toward biological experimentation. A chapter by James Franck and Robert Platzman deals in a careful manner with the physical principles underlying photochemical and radiation-chemical reactions, with which both men have been concerned for so many years.

This chapter, although occasionally suffering from the complexities of the subject with which it deals, furnishes a concise and useful view of the contributions of physics to photochemistry and radiation-chemistry. The chapters by W. M. Dale and E. S. G. Barron review the literature and suggest interpretations for observing the effects of x-rays on biologically important compounds. R. E. Zirkle reviews the importance of "linear energy transfer" in radiobiological reactions and its implications as to the mechanism of action of ionizing radiation. The final two chapters in the first part of Volume One are by H. J. Muller and deal thoroughly and exhaustively with the myriad observations on radiation effects in genetics. These two chapters encompass over 200 pages, yet despite the length, the usually lucid and stimulating style keeps the reader's interest. However, by comparison with some of Muller's other reviews, notably the Pilgrim Trust lecture (in which his imagination was permitted to roam more freely from the experimental findings, and which did not deal at such length with specific controversies in this specialized field) these chapters suffer somewhat. The reader may also be occasionally annoyed by the fact that the reviews are written in such a manner as to give the impression that a greater proportion than seems justified of the critical and pertinent evidence in genetics originated in the writer's own domain. A third impression and criticism, meant kindly from one who is not a specialist in the field discussed, is that alternative explanations of given phenomena are sometimes, it appears, too readily dismissed. Several examples might be cited in which I would myself share the general conclusion expressed, but which may yet not be so altogether sure as perusal of the volume might indicate. These are the discussions of position effects, which are considered as anomalies that occur never or with great infrequency outside of *Drosophila*. Whether position effects occur in other species depends, in part, upon the method of detection, and it does not seem justified to dismiss positional interaction between genes simply because detection may not be adequate or because it simplifies the over-all picture of genetics. In the discussion of mutagenicity and carcinogenicity the author uses the opposite type of reasoning. Despite preliminary experiments that suggest a negative correlation within the experimental material tested (between carcinogenicity and mutagenicity), Muller concludes: "On returning to the original question of whether the effect of radiation in producing gene mutation forms the basis of its effect in producing malignancy it will be seen that a comparative survey of the results not only with radiation of different types, but also with other agents now makes this view—better in the light of these results to be termed a theory—highly probable."

Muller's discussion of the long-term effects of low-level radiation on the genetic constitution of large human populations verges on the alarming. One gets the impression that even a slight increase in the normal rate of mutation will appreciably accelerate the arrival of the disaster approaching from the direction of spontaneous mutation. While such pessimism would probably be justified on the basis of present-day eugenic standards, it does seem conceivable that selective methods based on technological findings still in the future may combine with social eugenic programs whose over-all result would be a rapid and progressive improvement in the gene population.

Part Two of Volume One deals in a well-documented series of papers with further genetic effects of radiation in animals and plants. It includes interesting chapters on the mouse genetics experiments being carried on in Oak Ridge by W. R. and L. B. Russell, deals with a number of pathological effects of radiation from the developmental, anatomical, and physiological point of view, blood effects, and general histological changes, and concludes with the problem of carcinogenesis.

All in all, it is the impression of this reviewer that *Radiation Biology* is a worthy and thought-provoking sequel to Lea's earlier work, and that it will be an indispensable reference work for workers in radiation biology.

BERNARD L. STREHLER

LUMINESCENCE AND THE SCINTILLATION COUNTER. *By S. C. Curran. Academic Press, New York; Butlersworths Scientific Publications, London.* $5.80. x + 219 pp.; ill. 1953.

This compact volume is an excellent and concise treatment of scintillation counters, their components, application, and the fundamental principles of their operation. The book is divided into a number of logical sections, the first chapter giving a general introduction to the principles and history of scintillation detectors. The author then discusses the nature of elementary particles and electromagnetic radiation and proceeds with the classes of effect which radiation may have on matter. Since the emission of electrons from metallic surfaces during electron bombardment is the underlying physical framework of the construction of modern photomultipliers, secondary emission and the factors which influence it are discussed, and this is followed by a treatment of the general properties of electron multipliers. The photomultiplier is shown to be a special type of electron multiplier.

The next chapter is concerned with a description of particular properties of different commercially available photomultipliers. Such questions as those of resolving time and amplitude resolution are discussed briefly. The other half of the scintillation counter is, of course, the scintillating solid or liquid, which is used to produce light which the photomultiplier can detect. The next section of the book deals first with luminescence in solids, the general nature of the process and the factors which influence it. Since organic crystalline

solids, or acrystalline or amorphous solids and liquids have been finding an increasing use in scintillation spectroscopy, the next section is concerned with the fluorescence of organic solids and liquids, and is followed by a chapter on the methods of preparation of these materials. The next chapter deals with the properties of the crystals and liquids which are thus prepared, and the last three chapters take up specific and more general applications of the scintillation counters, the circuitry involved, special applications of multiplier tubes, such as quantum counting, and coincidence and other types of discrimination circuits. Curran's style of presentation is most lucid and informative. Little time is lost with unnecessary words, while in most cases the treatment is quite adequate for the purposes of the semi-specialist. All in all, this book would seem to be a valuable asset on the bookshelf or laboratory bench of workers in luminescence and scintillation spectroscopy.

BERNARD L. STREHLER

BIOCHEMISTRY

THE KINETIC BASIS OF MOLECULAR BIOLOGY. *By Frank H. Johnson, Henry Eyring, and Milton J. Polissar. John Wiley & Sons, New York; Chapman & Hall, London.* $15.00. x + 874 pp.; ill. 1954.

The fact that living organisms do not exhibit the chemical behavior characteristic of reactions at equilibrium has been accepted for some time as an axiom of biology. It thus appears that all studies of biological phenomena must concern themselves with considerations of kinetics and with the problem of how mechanisms can be elucidated from rate studies. This volume of almost 900 pages represents an impressive effort on the part of the authors to bring together for discussion a large number of papers dealing with a variety of types of biological processes. The book is plentifully illustrated with charts and curves, all of which have been redrawn from original sources, a change that certainly facilitates reading them. There are more than 1000 references to original data.

Beginning with a clear and concisely written introduction to absolute reaction-rate theory, there follow chapters on: the basis, fundamentals, principles and essentials of, respectively, thermodynamics, classical mechanics, quantum mechanics, and statistical mechanics. It is not quite clear just what function these chapters are intended to serve. The reader ought to know a good deal more about thermodynamics than is presented here, while the mathematical background required for the other chapters is such that the unprepared cannot follow much of the argument. The next chapter is an exposition of the methods used in the calculation of reaction rates for a 4-atom reaction. It is of great value in showing how very complex this situation can be. There follows a chapter on bioluminescence which is both a summary of the available literature and an interpretation of certain aspects of mechanism. Further, this chapter provides a useful introduction to the extensive application of data on luminescence to various problems to be considered later. Temperature is the subject of an informative chapter, one that develops the principal theme of the book, viz., that optimal temperatures for biological processes result from the competition between two opposing processes, (a) the tendency for the velocity of reactions to increase with temperature, and (b) the tendency for the catalyst of the reaction to become either reversibly or irreversibly inactivated with rise in temperature. The effects of hydrostatic pressure on chemical reactions are considered in a following chapter with special emphasis on the effects of pressure on protein denaturation. Since both pressure and temperature affect the kinetics of both cellular processes and the denaturation of purified protein systems, the authors have, quite understandably, attempted to relate these two processes. If bioluminescence is inhibited by a temperature of 35°C., the general picture that pressure restores bioluminescence to control values by inhibiting the volume increase associated with reversible luciferase denaturation must be regarded with some reservation. Experience with common proteins is such that thermal inactivation is usually not measurable at temperatures as low as 35°C., while biological temperature optima are often associated with such temperatures. One may, of course, imagine much more sensitive proteins, but *Cypridina* luciferase is not thermally denatured at 40°C., and the results with tobacco mosaic virus show that while at 70°C. this material behaves as expected, at 30°C. pressure greatly accelerates inactivation. This point is of further relevance when the data of the next chapter on the action of inhibitors are considered. Here the effects of various substances on the luminescent reaction of bacterial suspensions are related to the theory that inhibitors are effective because they promote the same sort of enzymatic changes as does temperature. The results obtained seem to underline the fact that both ethanol and ethyl urethane are unsuitable substances for studies of narcosis because these molecules are ambivalent in that they combine with or interact with both proteins and lipids. The higher urethanes, which may be expected to be more typical of liposoluble narcotics, do not conform to theory. There is a most interesting discussion of the irreversible effects of drugs and inhibitors as used for disinfection. It would seem that many of the postulated kinetic mechanisms are most applicable to the irreversible effects considered here.

There follow three chapters that deal with diffusion through and potentials across membranes, with the nerve impulse, and with the contractile process in muscle. These are characterized by a lucid presentation and a certain rigor in the analysis of various ionic effects that is altogether satisfactory. The nature of ion pumps

is examined from a physico-chemical viewpoint, and various types are classified. The kinetic situations responsible for the various types of steady-state conditions to be expected in membranes are developed, primarily in connection with a theory for excitation which the author presents. Finally there is a review of the problem of muscle contraction, together with an interpretation of the data in terms of a very interesting model. The last chapter is a stimulating theoretical study of potential energy barriers in diffusion, and considers the kinds of effects that can be treated as membrane phenomena.

The appearance of this book, which is to be regarded in very many ways as a work of the first importance, is bound to engender much discussion among biologists as to the interpretations that are to be placed upon heats and entropies of activation and reaction. Current reaction-rate theory requires the use of a rather large number of what, in biological work, can only be regarded as empirical constants. Since at least several of these are almost arbitrarily adjustable, the fact that data fit calculated curves cannot honestly be used to prove the validity of the theory.

L. J. MULLINS

TEXTBOOK OF BIOCHEMISTRY.

By Edward Staunton West and Wilbert R. Todd. The Macmillan Company, New York. $12.00. x + 1345 pp.; ill. 1953.

Any student who is thoroughly familiar with the content of this book would be well acquainted with biochemistry up to about 1947–48. Unfortunately, the preparation of such a large and comprehensive work takes so much time that it cannot also include the most recent findings in specialized fields. The book is organized along conventional lines. The first 6 chapters deal with the physical principles underlying biochemistry and living systems. There follow chapters on the constituent molecules of living things, a series of chapters on the physiological aspects of biochemistry, such as digestion, absorption, detoxication, respiration, and homeostatic mechanisms. More specialized chapters are devoted to the transformation of the elements of living things. Nutritional problems are then considered, while treatments of the metabolism of inorganic elements, the structures and functions of hormones, vitamins, and antimetabolic agents conclude the book. Although the book appears on the whole to be a worthwhile textbook, it suffers from several deficiencies. The most notable of these is the fact that no attempts were made to revise the manuscript in such important and rapidly developing fields as nucleic acid metabolism and structure, photosynthesis, and the function of Coenzyme A, to mention just a few. Nevertheless, this appears to be one of the most thorough and carefully written of the available general textbooks on biochemistry.

BERNARD L. STREHLER

FORTSCHRITTE DER CHEMIE ORGANISCHER NATURSTOFFE. *Volume XI.*

Edited by L. Zechmeister; authors, A. Albert, K. Brückner, R. B. Corey, K. Freudenberg, H. H. Inhoffen, R. Lemberg, L. Pauling, S. Peat, H. Schmid, and W. A. Schroeder. Springer-Verlag, Wien. $18.00. viii + 458 pp.; ill. 1954.

This eleventh volume of the progress reports is of special interest for biochemists. In the first article S. Peat discusses the constitution of starch, the problem of its branching, and the action of the newly discovered Z-, R-, Q-, and D-enzymes. Articles on the structure of lignin (K. Freudenberg), on recent developments in the chemistry of D-vitamins (H. H. Inhoffen and K. Brueckner) and on the structure and biogenesis of natural chromones in plants (H. Schmid) are followed by an important article of L. Pauling and R. B. Corey on the configuration of peptide chains in proteins. The dramatic development of the concept of helical structures is presented very impressively; the complicated experimental material which led to the new ideas is made understandable by a lucid presentation and by excellent illustrations. In another outstanding contribution W. A. Schroeder describes the analysis of proteins by column chromatography; the article is particularly valuable because of numerous critical remarks based on personal experience of the author. Progress in the chemistry and biosynthesis of natural porphyrins is treated authoritatively by R. Lemberg. The last chapter, written by A. Albert, is devoted to the amazing development of pteridine chemistry. The pteridine ring, until recently unknown, occurs not only in all vitamins and growth factors of the folic acid series, but also in white, yellow, and red pigments of the insects, fluorescent substances of fish scales, and in urinary pigments. The bibliography of all articles includes papers published in 1953. The book is highly recommended as an excellent source of data on the important fields covered by its contributors. Professor Zechmeister is to be congratulated for the outstanding quality of this volume.

F. HAUROWITZ

ADVANCES IN ENZYMOLOGY *and Related Subjects of Biochemistry. Volume XIV.*

Edited by F. F. Nord. Interscience Publishers, New York and London. $10.50. x + 470 pp.; ill. 1953.

ADVANCES IN ENZYMOLOGY *and Related Subjects of Biochemistry. Volume XV.*

Edited by F. F. Nord. Interscience Publishers, New York and London. $11.00. x + 548 pp.; ill. 1954.

This series of valuable monographs needs little introduction to the customers of this journal. The following subjects are covered in these two volumes:

Volume XIV: Probleme des Energietransports innerhalb lebender Zellen, by Bucher; Pantethine and Related Forms of the *Lactobacillus bulgaricus* Factor, by Snell and Brown; Metabolism of Phenylalanine and Tyrosine, by Lerner; Oxidation of Proteins by Tyrosinase and Peroxidase, by Sizer; Chemismus der organischen Katalyse, by Langenbeck; Enzymic Isomerization and Related Processes, by Leloir; Suggestions for a More Rational Classification and Nomenclature of Enzymes, by Hoffmann-Ostenhof; Quelques Techniques Nouvelles pour l'Étude de la Structure des Protéines, by Desnuelle; Adsorption Studies of Enzymes and Other Proteins, by Zittle; Principles and Procedures in the Isolation of Enzymes, by Schwinner and Pardee.

Volume XV: The Mechanism of Enzymic Oxidoreduction, by Leach; Thermodynamique des Réactions Immunologiques, by Würmser; Chemistry, Metabolism and Scope of Action of the Pyridine Nucleotide Coenzymes, by Singer and Kearney; Alternate Pathways of Glucose and Fructose Metabolism, by Racker; Enzymic Mechanisms in the Citric Acid Cycle, by Ochoa; Mechanism of Action of Hydrolytic Enzymes, by Lindley; Enzymic Synthesis of Polysaccharides, by Stacey; Urea Synthesis and Metabolism of Arginine and Citrulline, by Ratner; Thiaminase, by Fujita; Rennin and the Clotting of Milk, by Berridge; Die Struktur des Tabakmosaikvirus und seiner Mutanten, by Schramm.

DAVID B. TYLER

EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE. *Quatorzième Série.*

By P. Cartier, E.-B. Chain, J.-E. Courtois, Ch. de Duve, M.-F. Jayle, F. Leuthardt and E. Testa, A. de Muralt, F. Tayeau, R. Wolff and Ch. Wunderly; edited by Michel Polonovski. Masson et Cie., Paris. 2,200 fr. (paper). 283 pp.; ill. 1952.

The current volume of this informative series contains a number of reviews which will be of interest to biologists. Recent advances in carbohydrate metabolism are discussed by Chain, fructose metabolism by Leuthardt and Testa, the role of phosphorus in biochemistry by Courtois, biosynthesis and intermediary metabolism of follicular hormones by Jayle, physicochemical aspects of nerve conduction by de Muralt, vitamin B_{12} by Wolff, enzyme mechanisms in bone formation by Cartier, antigen-antibody reactions by Tayeau, and the separation of cellular constituents by differential centrifugation by de Duve. There is also a brief note by Wunderly on paper electrophoresis.

The critical approach of most of these reviews, the use of appropriate experimental data to illustrate particular points, and the extensive bibliographies all serve to enhance the value of these reports on the current status of selected fields of biochemical endeavor.

F. P. CHINARD

CHEMICAL PATHWAYS OF METABOLISM. *Volumes I, II. Edited by David M. Greenberg. Academic Press, New York.* $11.00. (I) xii + 460 pp.; ill. (II) x + 384 pp.; ill. 1954.

The Academic Press is not lackadaisical in putting out "series" books of this type. They have been starting quite a number of them—most of them are of interest to the specialist. The purpose of this series is also to survey our knowledge of the chemical steps in the processes of assimilation and dissimilation in living organisms.

Volume I contains the following reviews: Free Energy and Metabolism (Arthur B. Pardee); Enzymes in Metabolic Sequences (David E. Green); Glycolysis (P. K. Stumpf); The Tricarboxylic Acid Cycle (H. A. Krebs); Other Pathways of Carbohydrate Metabolism (Seymour S. Cohen); Biosynthesis of Complex Saccharides (W. Z. Hassid); Fat Metabolism and Acetoacetate Formation (I. L. Chaikoff and G. W. Brown, Jr.); and Sterol and Steroid Metabolism (D. K. Fukushima and Robert S. Rosenfeld).

Volume II contains a number of critical reviews dealing with the recent literature of the following subjects: Nitrogen Metabolism of Amino Acids (P. P. Cohen); Carbon Catabolism of Amino Acids, Synthetic Processes involving Amino Acids, and Metabolism of Sulfur-Containing Compounds (David M. Greenberg); Enzymatic Syntheses of Peptide Bonds (H. Borsook); Purines and Pyrimidines (Martin P. Schulman); Nucleotides and Nucleosides (Leon A. Heppel); and Metabolism of Heme and Chlorophyll (S. Granick).

DAVID B. TYLER

CELL CHEMISTRY. *A Collection of Papers Dedicated to Otto Warburg on the Occasion of His 70th Birthday. Edited by Dean Burk. Elsevier Publishing Company, Amsterdam, London, Houston, and New York.* $7.50. 362 pp.; ill. 1953.

This collection of original papers by a number of investigators is contained in Volume 12 (1953) of *Biochimica et Biophysica Acta* and was dedicated to Otto Warburg on his 70th birthday.

THE VITAMINS. *Chemistry, Physiology, Pathology. Volume I. Edited by W. H. Sebrell, Jr. and Robert S. Harris.*

Academic Press, New York. $16.50. xiv + 676 pp.; ill. 1954.

This first of a series of three volumes is devoted to a critical treatment and review of the various aspects of vitamin research. Competent contributors have been chosen to summarize critically and to discuss current knowledge concerning the chemistry, industrial production, physiology, biochemistry, estimation, occurrence, deficiency effects, pharmacology of, and requirements for, each vitamin. Since this is primarily a reference work, an extensive bibliography has been included. Special emphasis has been given to the chemistry and physiology of the vitamins with presumably secondary treatment devoted to the clinical manifestations. The vitamins are presented alphabetically; and Volume I is devoted to the vitamins A and the carotenes, ascorbic acid, vitamin B_{12}, and biotin. The discussions are by 21 contributors.

There is a good presentation by N. A. Milas of the chemistry and industrial preparation of the vitamins A and carotenes. The biochemical systems of this group are handled by George Wald and are almost completely concerned with the visual biochemistry of vitamin A, a commendable review of the present state of knowledge on the subject. H. H. Inhoffen and H. Pommer deal with the various methods of determination, standardization of activity, and occurrence of vitamin A, while the effects of vitamin A deficiency and of hypervitaminosis in animals and man are given by S. B. Wolbach and K. E. Mason, respectively. The latter also covers the vitamin A requirements of human beings, while F. H. Mattson reviews that of other animal species.

The discussions of ascorbic acid occupy approximately one-third of the volume and follow essentially the plan indicated above for vitamin A. The chemistry and industrial preparation of ascorbic acid are reviewed by Fred Smith, and biochemical systems by L. W. Mapson. The latter author has very adequately organized and condensed the vast body of literature on biochemical aspects of this vitamin, and has thus furnished a basic background for the student in the field. The analytical features, as well as the occurrence of vitamin C in food, are reviewed by Mamie Olliver, and requirements and deficiency effects in animals and humans are discussed by M. E. Reid and R. W. Vilter.

Vitamin B_{12} receives an up-to-date treatment by the workers who have been most active in developing that field. The group at Merck & Co., represented by D. E. Wolf and Karl Folkers, reviews the chemistry of the compound. H. M. Wuest summarizes its industrial preparation, while T. H. Jukes and W. L. Williams of the Lederle Laboratories handle the biochemical aspects, including determination, occurrence, biogenesis, deficiency, and pathology of the vitamin. F. H. Bethell covers its pharmacological and deficiency aspects in human beings.

Biotin, the fourth and last vitamin included in this volume, is covered in virtually all its aspects by Paul György, except for a short section on microbiological estimation prepared by E. E. Snell.

To judge from the high quality of Volume I, there is little question that *The Vitamins* will be a very useful set for both the student and the worker in the fields of nutrition and biochemistry. In my own opinion, its only obvious advantages over similar books in the field, such as Rosenberg's *Vitamins* or Eddy's *Vitaminology*, to name two, are its up-to-date coverage and its greater detail. The latter point might very easily be reinterpreted as a handicap, since it may serve to detract from the fundamental values. It is my guess, however, that these volumes will not enjoy too wide a sale and probably not too wide a circulation in view of its prohibitive price (see above). Such high-priced editions, apparently the present trend of the Academic Press, tend to restrict distribution of the volumes to departmental libraries, for the most part, and to make them unattainable by the biologist for his own book shelf.

ALVIN NASON

THE PROTEINS. *Chemistry, Biological Activity, and Methods. Volume II, Part A.*

Edited by Hans Neurath and Kenneth Bailey. Academic Press, New York. $14.00. x + 662 pp.; ill. 1954.

Volume I (in two parts) of this comprehensive treatise on the proteins deals with their physical and chemical properties. The second volume, of which this is the first part, is concerned with their biological activity, role in metabolism, and distribution in nature. The very high standard established in the first volume is maintained here. The contents are as follows: Nucleoproteins and Viruses (R. Markham and J. D. Smith); The Oxidizing Enzymes (T. P. Singer and E. B. Kearney); Respiratory Proteins (F. Haurowitz and R. L. Hardin); Toxic Proteins (W. E. Van Heyningen); Milk Proteins (T. L. McMeekin); Egg Proteins (R. C. Warner); Seed Proteins (S. Brohult and E. Sandegren); Proteins and Protein Metabolism in Plants (F. C. Seward and J. F. Thompson); and Protein Hormones (C. H. Li).

It is obviously impossible in a brief review to deal separately with each article. One can only note that each of the reviewers has made notable contributions to the field under discussion. A high standard has been maintained throughout, and the editors are due congratulations on their choice of authors, their general editing, and their decision not to let the size of the treatise get out of hand; it would have been simple to expand the treatise to many times its present size. Instead we have a treatise, comprehensive enough for a first survey of each field and sufficiently compact to be kept on the desk of the biochemist and the biologist who is interested in the functional aspects of living matter. The only unfortunate feature of the treatise is

the relegation of its indexes to the second part of each volume; this is perhaps a necessary economy, but one which makes its use as a reference a little more cumbersome than necessary. However, this is only a minor failing in a notable achievement. The treatise will be the standard reference on proteins for years to come.

EMIL L. SMITH

THE CHEMICAL STRUCTURE OF PROTEINS. *A Ciba Foundation Symposium.*

Edited by G. E. W. Wolstenholme and Margaret P. Cameron. Little, Brown & Company, Boston. $6.00. xii + 222 pp. + 6 pl.; text ill. 1954.

This published account of an international symposium held at the Ciba Foundation in London on December 1st to 3rd, 1952, contains all the papers, and the informal general discussions as well. The discussion centering on the structural determination of peptides was ably covered by some of the foremost workers in the field. Particular emphasis was given to purification by counter-current technics (Craig, Stein, Porter, Synge, Boulanger, Felix, Grossman, Schroeder) and to structural determination by step-wise degradation (Edman, Turba, Wieland, Smith). Of course, considerable emphasis was given to methods of determining the terminal amino acids of peptides and protein (N-terminal, Desnuelle and Fraenkel-Courat; C-terminal, Chibnall and Fromageot).

This book should be particularly valuable to workers in this field for the wealth of detail to be found not only in the formal presentations but also in the ensuing discussions. These have been excellently edited for readability without losing their informal intimacy. The reader is thus given frequent views of the ramifying implications of certain data and also is cautioned by the alternative interpretations of results.

WALTER L. HUGHES

SOME CONJUGATED PROTEINS. *A Symposium. Six lectures presented at the Ninth Annual Conference on Protein Metabolism, Bureau of Biological Research, Rutgers University, The State University of New Jersey, January 30–31, 1953.*

Edited by William H. Cole. Rutgers University Press, New Brunswick. $1.75 (paper). vii + 73 pp.; ill. 1953.

This collection of 6 papers comprises The Anatomy of Hemoglobin and some Functions of its Parts (S. Granick); Cytochromes in the Mammal (W. W. Waino); On the Problem of Nucleoproteins (E. Chargaff); The Metabolism of Virus-Infected Bacteria (S. S. Cohen); Lipoproteins (J. L. Oncley); and Mucoproteins and Mucoids (Karl Meyer). These are relatively short, authoritative reviews of the biochemistry of examples of the conjugation of proteins with various other substances, of unquestionable biological importance.

EVELYN HOWARD

CHROMATOGRAPHISCHE METHODEN IN DER PROTEIN-CHEMIE *einschliesslich verwandter Methoden wie Gegenstromverteilung, Papier-Ionophorese.*

By Fritz Turba. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM. 69.— viii + 358 pp.; ill. 1954.

Among the numerous reviews and treatises on chromatography published during the last few years, Turba's book excels by its completeness, by the inclusion of related methods such as counter-current distribution, and by the large number of remarks based on the great personal experience of the author. It is a book for those who want to learn not only chromatography but also methods to avoid the difficulties and pitfalls of this powerful analytical tool. The directions given in the book are very clear and accurate; they are accompanied by a large number of excellent illustrations. The description of methods is so complete that the reader need not consult the original articles. Among the problems covered, the following may be mentioned: standardization of absorbents and solvents; survey of the commercially obtainable ion exchange resins (chiefly American products); methods for end-group determinations and for the stepwise degradation of peptides. The degradation of insulin and other natural peptides and proteins is described in detail. A special section is devoted to the incorporation of radioactive isotopes into proteins or peptides and their chromatographic separation. The last sections of the book deal with paper electrophoresis, electrophoresis convection, and related methods. This book I consider to be one of the best in this field and I recommend it highly to all those who want to use chromatographic methods.

FELIX HAUROWITZ

METABOLISM OF STEROID HORMONES.

By Ralph I. Dorfman and Frank Ungar. Burgess Publishing Company, Minneapolis. $4.00. vi + 170 pp.; ill. 1953.

This volume, intended as a reference for the neophyte as well as the expert in the field of steroid hormone metabolism, should become a useful desk companion to all students of the steroids. The 100-odd steroids that have been isolated and identified are here arranged according to the sources from which they have been isolated and the reactions which they have been shown to undergo, both in vivo, and in vitro by means of perfusion studies and enzyme systems. Microbiological reactions on steroids are included, and the evidence regarding biosynthesis is assembled. The literature is

documented conveniently throughout the tables. A large amount of information has been arranged in an orderly system of metabolism of the known neutral steroids. The authors are to be congratulated for this attack on the conservative chaos which has hitherto tended to prevail in the steroid field. The volume should encourage those who are searching for biological meaning among the biochemical trees of the very dense steroid forest.

EVELYN HOWARD

RECENT PROGRESS IN HORMONE RESEARCH. *Volume IX. The Proceedings of the Laurentian Hormone Conference.*

Edited by Gregory Pincus; Committee on Arrangements, R. W. Bates, G. Grant, R. D. H. Heard, A. D. Odell, E. C. Reifenstein, Jr., A. White, and G. Pincus. Academic Press, New York. $9.50. x + 468 pp. + 1 pl.; text ill. 1954.

This volume presents the results of a special interim conference under the auspices of the Laurentian Hormone Conference to deal with Methods of Steroid Determination in Blood and Urine, a reasonably important piece of information that does not appear on the title page. Nor is it anywhere recorded for posterity just when this meeting occurred. With the possible exception of some generalizations by Dorfman on the metabolism in vivo of neutral steroid hormones, the general impression on perusing this volume is, to use a phrase of one of the participants, "overwhelming both as to results and to methods." Some problems have been indigenous to steroid assay work since the middle thirties: storage, preservation, and hydrolysis. Batteries of chicks, capons, and rats have long since yielded to the chromatograph and color reactions, but questions of stability, artefacts, and the fate of the very considerable fraction of steroid that does not appear in the analyses remain. The summarizing discussions were ably handled by Gregory Pincus. This is a field of enormous scope and intricacy, and destined to become more so by the addition of radiotracers for the steroid hormones. It is interesting that in this welter of pure methodology O. Hechter sees still a place for emotional factors in the choice and appraisal of techniques.

The volume is dedicated to Konrad Dobriner.

H. R. CATCHPOLE

THE ALKALOIDS. *Chemistry and Physiology. Volume IV.*

Edited by R. H. F. Manske and H. L. Holmes. Academic Press, New York. $8.50. x + 358 pp.; ill. 1954.

This is a detailed account of the chemistry and biosynthesis of the following classes of isoquinolines: Simple Isoquinoline Alkaloids, Cactus Alkaloids, Benzylisoquinoline Alkaloids, Protoberberine Alkaloids, Aporphine Alkaloids, Protopine Alkaloids, Phthalideisoquinoline Alkaloids, Bisbenzylisoquinoline Alkaloids, Cularine Alkaloids, α-Naphthaphenanthridine Alkaloids, Erythrophleum Alkaloids, and Aconitum and Delphinium Alkaloids. It will be of interest and value only to those actively working in this field. It should be, however, in all chemical libraries as a reference work.

DAVID B. TYLER

DIE CHEMIE DER NATÜRLICHEN ALKALOIDE *mit besonderer Berücksichtigung ihrer Biogenese. 1. Hälfte.*

By Gertrud Woker. Ferdinand Enke Verlag, Stuttgart. DM. 78.— (paper). 449 pp. + 1 folded chart; ill. 1953.

In this very unusual book the author emphasizes the historical viewpoint in the discovery, chemical analysis, and synthesis of the alkaloids, and discusses extensively possible mechanisms of their biosynthesis. The physical and chemical properties of the alkaloids are described in numerous footnotes only; these form a large portion of the book. In this first of two volumes that will form the complete work, the following classification is used: (I) betaines formed from amino acids; (II) alkaloids formed from codehydrogenases; (III) alkaloids with a side-chain in α-position. Group II comprises cytisine, sparteine, nicotine, quinine, and related substances; group III comprises coniine, pelletierine, atropine, and related alkaloids; in this group the steroid alkaloids and the veratrum alkaloids are also discussed. The author assumes that the alkaloids treated in group II are formed in nature by reduction of the ribose residue of nicotinamide riboside and secondary ring formation. While these are interesting speculations, they are not based on experimental evidence. Most biochemists will be reluctant to classify quinine and similar substances as derivatives of codehydrogenases. The book is certainly interesting reading for those acquainted with alkaloid chemistry, but does not seem to be suitable as an introduction into this field.

F. HAUROWITZ

STARCH *and Its Derivatives. Volumes One and Two. Third Edition (Revised).*

By J. A. Radley. John Wiley & Sons, New York. $10.00 per vol. (I) x + 510 pp. + 13 pl.; text ill. (II) xii + 466 pp. + 35 pl.; text ill. 1954.

Those who are acquainted with the subject know that the literature of the chemistry and technology of starch is very voluminous. Thousands of papers have been written on the subject. Radley undertook the difficult task of summarizing the existing knowledge, which resulted in his *Starch and Its Derivatives* in 1940. Due to

the rapid expansion of the field, the author deemed it necessary, as soon as this monograph was published, to launch a second enlarged edition. The present edition, the third, is further expanded and is put out in two volumes. The general method of presentation used in the previous editions nevertheless remains the same. A number of new chapters have been added, and many of the older ones have been completely rewritten and extended by authorities in each particular field. However, the reader is probably aware that no completely up-to-date review of an active field is possible, no matter how conscientious the author may be. No sooner is the survey off the press than certain aspects are out of date. Radley's third edition is no exception.

Volume I is concerned primarily with the fundamental aspects of chemistry and with the biochemistry of starch. It is divided into two parts, the first dealing with The Structure and Reactions of Starch, and the second with Amyloses and their Action on Starch. Chapters for Part 1 were contributed by S. Peat, L. Hough and J. K. N. Jones, T. C. Schoch, R. L. Whistler, G. V. Caesar, R. M. Hixon and B. Brimhall, and E. E. Degering. The chapter on waxy cereals by A. M. Hixon and B. Brimhall appears to be the first comprehensive account of the botany, genetics, and agronomy as well as the chemistry of these products, and should be of interest to those concerned with the subject. Part 2 was written entirely by J. A. Radley, the editor and chief contributor.

Volume II deals with the industrial aspects and technological applications of starch and its derivatives. It consists of three parts under the following topics: (1) The Manufacture of Starch and Starch Products; (2) The Industrial Applications of Starch and Starch Products; and (3) Analysis of Starch and Starch Products. In addition to Radley, the following authors participated in this volume: R. W. Kerr, L. M. Christensen and L. A. Underkofler, C. W. Bice and W. F. Geddes, C. C. Kesler and W. G. Bechtel, and C. Paine.

Since a considerable part of this survey is written by Americans, the work reflects to a large extent the industrial practices and trends of this country. Viewed as a whole, the monograph can be recommended as a judicious combination of the theoretical and practical approaches. It represents a valuable contribution to the literature of starch chemistry and will be greatly appreciated by chemists and biochemists. In these days, when the time necessary for reading the original scientific literature tends to become so great as to interfere with research, authoritative and critical monographs such as these are increasingly valuable.

W. Z. Hassid

MICROBIOLOGY

An Introduction to Bacterial Physiology. *By Evelyn L. Oginsky and Wayne W. Umbreit; drawings by Evan L. Gillespie. W. H. Freeman & Company, San Francisco.* $7.25. xii + 404 pp.; ill. 1954.

This textbook should be used by undergraduates who have completed courses in general bacteriology and organic chemistry, and by advanced workers in other fields who desire to use bacteria as a weapon of research. The authors have achieved their goal precisely.

The text is very readable, nearly conversational at times, and concise—perhaps too concise on certain points. No doubt many readers will be aroused by the brief, and sometimes light, treatment of such subjects as the Pasteur effect, oxidative phosphorylation, and assimilation.

Excellent judgment has been exercised in the selection of photographs. The illustrator is to be complimented for the originality shown in the atomic age drawings. The script of these illustrations is somewhat more difficult to read at a glance and will require some additional concentration on the part of the student, perhaps not with adverse results.

The authors have boldly indulged in the sport of healthy and provocative speculation, pointing to many unsolved but extremely interesting problems. In each case, however, speculation is labelled as such, and many of the existing problems are exposed. The book seems to be concerned only secondarily with providing information to the student, and to be primarily devoted to the stimulation of thought and action. Unfortunately, such ideals are attained in too few writings today. The well selected questions and references for each chapter drive this point home. Rote memory will fail entirely and excursions into other information sources are required. Instructors contemplating to use this book would do well to examine first the question lists. It will require a good man to keep up with this level and tempo.

The hidden advice to the student is excellent. Cautions, both implied and stated, about believing the literature are timely. The student is carefully led through the logical steps of the presentation and interpretation of data.

Of the 393 pages of text, 150 are devoted to metabolism in most of its facets. The most noteworthy attribute of this section is the clear distinction between the data obtained from bacteria and those derived from experiments with other organisms. The latter are, of course, necessary for a presentation of the over-all aspects of metabolism, but no sweeping generalizations for bacteria are drawn from the results of animal experiments.

The text is separated into 6 general sections, each prefaced by a well conceived introduction. Section One, Chapter One, on the Nature and Basis of Bacterial Physiology, should be required reading by all students of science. Section Two and Chapter Two concern Bacterial Anatomy, its cytological and cytochemical aspects. Section Three, Populations, includes chapters on Growth, Nutrition, the Effect of Environments, and Genetics. Section Five, Variations on a Theme, con-

siders the extremes encountered in the bacterial world, the autotrophic Self-Reliants and the hopelessly Dependent particles, the viruses and rickettsia. Section Six discusses the amazing Capacity of the Cell, including its ability to Adapt, to Survive, and to prey upon other living forms. While not a new idea, Virulence considered from a purely physiological standpoint is on much more solid ground than are the easier empirical efforts which haunt the problems of disease. As is the case with most good books, this one is not perfect. The very few typographical errors unfortunately occur at critical points. The authors appear to have departed from convention in their definition of turnover number as moles per second per mole, instead of moles per minute per mole. In the calculation of oxidation-reduction values for fermentation balances the values of oxygen and hydrogen have been reversed, as opposed to the present convention in which $2H = -1$ and $O = +1$. The novel dual presentation and explanations of energy concepts, while designed to be clearer, will probably contribute to the confusion and befuddlement usually attendant to this subject. On a quibbling note, the illegal abbreviation *Strep.* has been employed in place of *Streptococcus* or *S.*

This book is very highly recommended to all students of bacteriology, old and new, as well as to brothers and sisters in related fields.

RALPH D. DEMOSS

AUTOTROPHIC MICRO-ORGANISMS. *Fourth Symposium of The Society For General Microbiology held at The Institution of Electrical Engineers, London, April 1954.* *Cambridge University Press, New York.* $5.00. xii + 306 pp. + 1 pl.; text ill. 1954.

For the past four years the British Society for General Microbiology has held an annual symposium with international participation, to permit the exhaustive discussion of an important microbiological topic. The published proceedings of these symposia are a very valuable addition to the microbiological literature, for which we must be grateful to the initiative and enthusiasm of British microbiologists.

This volume, the fourth in the series, is devoted to autotrophic microorganisms. The stage is set by Woods and Lascelles with an admirable analysis of the elusive concept of autotrophy and the relationships between the autotrophic and heterotrophic ways of life. The biological background is supplied by Bisset and Grace, who give an adequate if somewhat dogmatic account of the taxonomy and systematic relationships of chemoautotrophic and photosynthetic bacteria. Butlin and Postgate review the economic importance, past, present, and future, of the autotrophs, and include a good deal of information on their roles as agents of geochemical change. The remaining articles are more specialized, and deal with particular groups of chemoautotrophic or photosynthetic organisms. At first sight the coverage appears spotty; but this is a reflection of the fact that almost no recent work has been done on some groups of autotrophs, and the areas of current activity are, in fact, quite fully represented. The physiology and metabolism of the *Thiobacillus* group are discussed by Baalsrud, who sums up in a fair and judicious manner the disputed questions of carbon dioxide assimilation and energy transfer in these organisms. Meiklejohn describes the nutrition, and Lees the biochemistry, of the nitrifying bacteria. The green and purple sulfur bacteria are reviewed by Larsen. He is, incidentally, the only author who adheres scrupulously to the nomenclatorial scheme for nutritional types printed at the front of the book; but he does so at the cost of having to designate his organisms as "photolitho-autotrophic bacteria." Elsden's article on the non-sulfur purple bacteria contains much new information on the light metabolism of organic compounds. It is unfortunate that no member of Kamen's group was present to discuss in extenso the fascinating work on photohydrogen production and nitrogen fixation by purple bacteria; however, Elsden provides a good if brief summary of their findings. The remaining contributions are concerned with green plant photosynthesis and related matters. Current notions about the mechanism of photosynthesis are sketched by Gaffron. His paper is particularly notable for a clear and simple treatment of facts and fancies about quantum efficiency, a subject which in recent years has evoked a dialectical ferocity scarcely equalled since the theological disputes of the early Christians. Blinks provides an authoritative account of the role of accessory (i.e., non-chlorophyllous) pigments in photosynthesis. Aspects of the nitrogen metabolism of green and blue-green algae are discussed by Syrett and by Fogg and Wolfe, respectively. Wassink analyzes some of the scientific and technical problems involved in the mass cultivation of algae, perhaps the most important of all the potential applications of autotrophy to human welfare.

The Cambridge University Press has made its expected contribution, by producing a very handsomely printed and bound volume at a modest price. Why do so few American publishers of technical works meet these standards?

R. Y. STANIER

HEALTH AND DISEASE

MEDICINE AND SCIENCE. *Lectures to the Laity, No. XVI, The New York Academy of Medicine.* *Edited by Iago Galdston. International Universities Press, New York.* $3.00. 160 pp.; ill. 1954.

This group of lectures to the "laity," the 16th in a well-known series on various phases of medicine, is addressed like the others to persons with some scientific interest

and background. The subjects, ranging from cybernetics to endocrinology, seem to have been chosen because of their recent prominence in scientific and popular publications. Six lectures cannot adequately describe the relationship between medicine and science, of course; they can only give a few examples of medicine's dependence on other fields of science and on the scientific method in its own sphere.

Norbert Wiener's informal description of cybernetics ends with the warning that the automatic factory may result in such a tremendous war potential or such staggering unemployment as to destroy us if science does not give at least as much attention to men as it does to atoms. The new impetus given to endocrinology by the discovery of ACTH and cortisone is discussed by Hans Selye and Paul Rosch in relation to their concepts of adaptation to stress. They also voice the need for theorists to lead and stimulate the empiricists in endocrine research. David Levy presents a fascinating description of experimental neuroses and psychopathology in animals that seem to parallel and offer a better understanding of similar processes in man. Harold Wolff gives a stirring account of the psychogenesis of certain diseases in man. Paul Burkholder's story of the discovery of antibiotics, our present knowledge and future possibilities, is supplemented by John McKeen's narrative of how large-scale industrial methods have made the wonder drugs plentiful and cheap.

Medicine and Science pleasantly and easily satisfies general intellectual interest in the subjects enumerated and illustrates some aspects of the general relationship.

PAUL A. LEMBCKE

THE DYNAMICS OF VIRUS AND RICKETTSIAL INFECTIONS. *International Symposium sponsored by the Henry Ford Hospital, Detroit, October 21, 22, and 23, 1953.*

Edited by Frank W. Hartman, Frank L. Horsfall, and John G. Kidd. The Blakiston Company, New York and Toronto. $7.50. xii + 462 pp.; ill. 1954.

Sponsored by the Henry Ford Hospital, and held in Detroit in October 1953, this symposium was attended by more than 400 scientists, including several from foreign countries. A wide variety of problems was discussed against the background of current concepts; in fact, the title is inadequate to describe the scope of the meeting. One came away feeling that he had been exposed to a most thorough, learned, and stimulating analysis of the current research frontier in virology. The six half-day sessions, comprising 33 papers, and including the discussions which occurred at the end of each group of papers, have been recorded, with a minimum of editing, in this attractive volume.

In planning the symposium an effort was made to integrate information obtained from studies with various kinds of viruses. Thus, in the same session investigations conducted with plant, animal, and bacterial viruses were presented. This scheme was especially effective in the first two groups of papers, comprising section I of the book, and entitled Mechanisms of Virus and Rickettsial Infections. The well-studied bacteria-virus system was used as a point of reference, and numerous comparisons and contrasts were made with infections involving animal and plant viruses. Most of this discussion was on the cellular level, a notable exception being one paper dealing with nutritional and environmental factors affecting the susceptibility of plants to virus disease.

Section II deals with Ecology and Pathogenesis and consists of 6 papers dealing in part with general and in part with specific questions of reservoirs, transmission, epidemiology, and factors influencing virulence.

The third section, concerned with Mechanisms of Immunity, includes 1 paper on poliomyelitis and 3 of a more general nature. Two of the latter discuss the use of living vaccines, and thus reflect a present trend in this direction.

Section IV, on Laboratory Diagnosis, contains one paper each on the psittacosis-lymphogranuloma venereum group and smallpox. Another discusses general problems, and two others deal with new approaches to laboratory diagnosis. One of these is the use of tissue culture techniques, utilizing mammalian cells. Although recent developments in this method of virus culture have centered around poliomyelitis virus, the potentiality of the methods as general tools in virology is already amply demonstrated. The other new approach to laboratory diagnosis discussed here is the rapid demonstration of small amounts of specific naturally occurring antigen. An especially promising method is the use of antibody coupled with a fluorescent dye, which under suitable conditions provides a visual labelling of the antigen-antibody reaction. By this technique microscopic amounts of antigen can be demonstrated in infected tissues or exudates.

Approaches to Prophylaxis and Therapy, constituting Section V, cover the present applications and limitations of chemotherapy in these infections. Also reviewed are several lines of investigation based on theoretical approaches to a general solution of the problem.

A good example of integration from various areas of study within virology, promoted by the symposium, is to be found in the discussions of the nature and significance of "non-infective virus." Protein components have been demonstrated in a variety of infected cells, which are chemically or immunologically related to "normal virus" but which are not infective. These substances have been interpreted as the result of incomplete maturation of virus particles, as break-down products of virus, and as by-products in the synthesis of "normal virus." Discussions of these alternative views appear

repeatedly throughout the volume, both in the formal presentations and in the recorded informal comments.

The texts of the papers are conveniently divided into sections marked in bold-face headings, so as to increase the usefulness of the book for purposes of study and reference. Such a device is especially valuable in the absence of either a breakdown in the table of contents, or an index. Tabular and graphic materials are adequate. Each paper is followed by a list of references. The book will be extremely useful to students of virology and to those in related biologic fields who wish to examine the present status of that subject.

FRANCIS B. GORDON

MANUAL OF CLINICAL MYCOLOGY. *Second Edition.*

By Norman F. Conant, David Tillerson Smith, Roger Denio Baker, Jasper Lamar Callaway, and Donald Stover Martin. W. B. Saunders Company, Philadelphia and London. $6.50. xii + 456 pp.; ill. 1954.

In this manual there is included the available, essential information regarding the diseases of man caused by fungi and the actinomycete group of bacteria. Each disease is treated from the standpoint of its symptomatology, mycology, pathology, immunology, prognosis, and treatment. The symptoms of the various diseases and all the information available in regard to treatment are discussed fully. Techniques used in isolating, culturing, and staining the organisms involved and in testing their pathogenicity tn laboratorn animals are included. The book is well-illustrated with 202 figures, of which 88 are new. These include reproductions of photographs illustrating disease symptoms, photographs of the fungi in culture, photomicrographs of affected tissues, and photomicrographs and drawings of the causal organisms. In a special section in the appendix, formulae for the various wet dressings, dusting powders, ointments, paints, and lotions recommended for treatment and control are added.

As a reference book, this manual should be very useful to mycologists as well as to diagnosticians, laboratory technicians, and practicing physicians. For each disease, a list of references from the literature is presented.

C. W. EDGERTON

MEDICAL MYCOLOGY LABORATORY MANUAL.

By Margaret Kelly Grady. Burgess Publishing Company, Minneapolis. $2.25 (paper). iii + 73 pp.; ill. 1954.

This manual, prepared for use in the laboratory by students studying the diseases of man caused by fungi and the actinomycete group of the higher bacteria, presents the methods of laboratory diagnosis and information in regard to the important characteristics of the various organisms. Techniques involved in preparing, staining, culturing, and isolating the organisms are emphasized. Outline drawings illustrating the vegetative and fruiting characters are included.

C. W. EDGERTON

THE PHARMACOLOGIC PRINCIPLES OF MEDICAL PRACTICE. *A Textbook on Pharmacology and Therapeutics for Medical Students, Physicians, and the Members of the Professions Allied to Medicine. Third Edition.*

By John C. Krantz, Jr., and C. Jelleff Carr. The Williams & Wilkins Company, Baltimore. $12.00. xxii + 1184 + 4 pl.; text ill. 1954.

This textbook has again gone into a fairly extensive revision—the third within 5 years and a record of some sort—but also an indication of the strange and exciting things that are happening in this field. The main change in the new edition is the expansion of several chapters, particularly those dealing with chemotherapeutic agents in tuberculosis and in hypertension. Also, a number of sections have been considerably reduced or deleted, particularly the chapter on the treatment of syphilis and rickettsial diseases. Furthermore, there are to be noted some changes in the roster of specialists who have partly contributed or criticized and reviewed various sections. Worthy of mention again is the section on anti-motion-sickness drugs, in which can be detected the deft touch of the Professor of Pharmacology of George Washington University, who, incidentally, is a most able and likeable individual. The result is one of the best chapters I have had the pleasure of reading. However, it seems to me, and here I am being purely objective, that the specialists who contributed to the same section in the 2nd edition (*Q. R. B.*, 26: 416. 1952) had just a shade defter touch—true, only a shade, but defter. This is an observation made only in the friendliest manner—and just to be objective, not controversial.

DAVID B. TYLER

STANDARD METHODS OF CLINICAL CHEMISTRY. *Volume 1.*

By The American Association of Clinical Chemists; editor-in-chief, Miriam Reiner. Academic Press, New York. $4.50. xii + 142 pp.; ill. 1953.

It is stated in the Foreword that the purpose of this collection of routine clinical chemistry methods is to "raise the standards of clinical chemistry" and "improve the medical care of the population." The methods or procedures are concerned with: amylase, bilirubin, calcium, carbon dioxide content, chloride, sodium, potassium, glucose, creatinine, lipase, alkaline and acid phosphatase, inorganic phosphate, albumin, globulin,

and total protein, urea, uric acid, and thymol turbidity. The methods are submitted by one group of workers and, as for *Biochemical Preparations* and *Organic Syntheses*, are checked by another group. The directions are clearly given, and there is generally a brief discussion of the limitations as well as the significance of the particular method under consideration.

The inclusion of certain procedures is, however, surprising. That for the determination of sodium and potassium by flame photometry is based on an instrument which is relatively little used in this country and which appears to have definite drawbacks; modifications were required before the instrument could be used for its intended purpose. The method for urea depends on the hydrolysis of urea with urease and the subsequent direct nesslerization of the solution. It seems of doubtful value to couple a notoriously empirical and frequently erratic colorimetric procedure to an exact but exacting enzymatic method. The gasometric hypobromite method is not so accurate but is much better suited to a routine clinical laboratory. The method chosen for the determination of chloride ion seems unnecessarily complex; there are available suitable electrometric procedures which require neither deproteinization nor an indicator for the end-point.

In spite of these drawbacks this volume will be valuable to those working in clinical chemistry laboratories; that the present volume will achieve fully its intended purpose is, however, doubtful. It is to be hoped that subsequent volumes will present the promised new and timely methods and modifications.

F. P. CHINARD

CLINICAL CHEMICAL PATHOLOGY.

By C. H. Gray. Edward Arnold & Company, London. 10s. 6d. vi + 138 pp.; ill. 1953.

This very neat, compact little reference book should be of value to medical students, internes, and the practitioner. It certainly should reacquaint them with certain chemical phases of disease and the limitations of the chemical methods of analysis. It should serve as a very handy reference book.

DAVID B. TYLER

LA MASSE AZOTÉE DE L'ORGANISME HUMAIN ET SES VARIATIONS PATHOLOGIQUES. *Rapports Présentés au XXIX^e Congrès Français de Médecine, Paris 1953 (Assocation des Médicins de Langue française)*

President du Congrès, Ph. M. Loeper. Masson et Cie., Paris. 1,100 fr. (paper). vi + Pp. 475–670; ill. 1953.

This is a collection of informative and critical reviews on the normal partition of nitrogen in human beings and on the variations in the amounts of nitrogen and in its partition occurring as a result of disease. Trémolieres and Derache summarize current data on this partition and the methods of estimating the volumes of the several body compartments. Delbarre and Benhamou discuss zone electrophoresis and paper chromatography as applied to the separation, identification, and quantitation of serum proteins and lipoproteins and urinary amino acids. Studies with isotopes are briefly presented by the Henriques; pediatric aspects of nitrogen metabolism are given in some detail by Mouriquand. The other reviews are on hormonal regulations (Mach and Muller), clinical aspects of nitrogen deficiency (Gounelle), cytochemical and cytological changes occurring in this deficiency (Verne), and the dietary regimens used in restoring nitrogen balance (Paris). Each review presents examples of the data on which current concepts are based and concludes with an extensive bibliography.

F. P. CHINARD

INTRODUCTION TO GENERAL PATHOLOGY

By Myrtle H. Coe. Burgess Publishing Company, Minneapolis. $2.25 (paper). iii + 107 pp.; ill. 1953.

This volume is an introduction to pathology for the student nurse. It is simplified, condensed, and bound in inexpensive, semi-looseleaf fashion, with backs of pages left blank for pertinent notes. A few diagrams and charts illustrate certain complicated concepts, but there are no other illustrations. Because of its inexpensive format, this book might serve as an adjunct to a lecture course in pathology for nurses, although many of the available nursing textbooks of pathology would seem preferable.

ELLA N. OPPENHEIMER

BASIC PATHOLOGY AND MORBID HISTOLOGY.

By D. B. Cater. The Williams & Wilkins Company Baltimore. $8.50. vi + 330 pp.; ill. 1953.

The author justifies this book on the basis that the student with his limited knowledge of clinical medicine frequently finds the altered histologic appearances of pathological lesions meaningless and pathology a dead science. "This book is designed to help the student who has just begun the study of pathology and finds the subject difficult." To accomplish this the author has used numerous charts and diagrams, camera lucida drawings in color and in black and white, and black-and-white halftones of gross lesions. The use of the photographic emulsion has been employed not at all. Unfortunately, the drawings of the gross specimens have very little resemblance to fresh or even to museum specimens. The camera lucida drawings are for the most part very well done; they emphasize the essential microscopic features without being merely diagrams.

The effort to make pathology clear is commendable. Introduction of numerous diagrams attempting to relate the physiological aspects with morbid changes has merit. Unfortunately at some points this practice has led to oversimplification and to the employment of assumptions that are not yet proved or that are untrue, simply to make things fit neatly. A student may find such a book helpful as an accessory textbook. In most instances the material given him here will be correct, but the undiscriminating student (and it must be admitted that students in general are not critical in evaluating new material) may grasp and retain items that will give him a poor perspective.

One of these recurring practices that I would question is the use of arbitrary ranges and percentages implying limits that in fact do not exist. For example, in the chart of leukemias and allied conditions, it is indicated that in myeloid leukemia there are 2.5 million or less red blood cells, whereas in lymphatic leukemia there are 3.5 million. Actually a wide range of blood counts is encountered in leukemias, and the level may vary from normal to extremely low levels. It is not always clear to students or, for that matter, to the reviewer whether the values given are supposed to represent those of a typical untreated case, or the range of values within which all patients with such a diagnosis should fall. An arbitrary range of 2 to 5 per cent of myeloblasts in the blood is given for myeloid leukemia; the fact is that the numbers of myeloblasts vary so widely that no arbitrary range such as this should be taught. On the same page Hodgkin's disease is characterized as radioresistant and lymphosarcoma as radiosensitive; in truth, some patients with Hodgkin's disease respond well to radiation while some patients with lymphosarcoma will do poorly. Similarly, it is hardly safe to characterize fibroadenoma of the breast as a benign tumor occurring in women 15 to 25 years old.

The foregoing remarks should not imply, however, that all of the text material is elementary. Some of the dissertations are rather scholarly and often advanced, with references to experimental and theoretical work that might better in some instances have been reserved for more advanced students. For example, there is little reason to include such extraneous items as "pro-myelocytes of Ferrata (myelocyte type A of Doan's classification)" in an introductory textbook.

The author's thesis that the student deserves some help in establishing concepts of pathology is a good one. Encouragement should be offered to whatever author can use some of Cater's approaches in achieving that goal.

RALPH M. KNISELEY

ENDEMIC GOITER. *The Adaptation of Man to Iodine Deficiency.* *By John B. Stanbury, Gordon L. Brownell, Douglas S. Riggs and Hector Perinetti, Juan Iloiz, and Enrique B. Del Castillo. Harvard University Press, Cambridge.* $4.00. xii + 210 pp.; ill. 1954.

The Andean Goiter Expedition was launched to take advantage of a unique opportunity to learn something about the physiology of the iodine-starved thyroid gland. The province of Mendoza is located in the extreme West-Central portion of Argentina near the Chilean border. Goiter has been endemic in this area for a long time, and all information supports the view that a lack of iodine is the principal etiological factor. Iodized salt had not been used to wipe out this endemic up to 1950, when Dr. Hector Perinetti of the Central Hospital in Mendoza visited the Thyroid Clinic of the Massachusetts General Hospital in Boston. It was decided to send an expedition to Argentina to study this goiter endemic by modern methods. The expedition was a joint enterprise of the Massachusetts General Hospital and the University of Cuyo in Mendoza and the Central Hospital there. The present monograph is a full report of its findings.

The basic question asked by the investigators was, "How does the thyroid safeguard hormone manufacture despite great difficulties in obtaining adequate amounts of the necessary raw material, iodine?" Newly introduced tools of thyroid physiology permitted the uncovering of certain new facts of iodine metabolism. It is no exaggeration to state that the answer could have not been found without the situation prevalent in Mendoza and without application of the tools, radioiodine and the antithyroid drugs. Moreover, the research was finished just in time, inasmuch as the sale of iodized salt has now been made mandatory in Mendoza province. The main results of the Mendoza expedition are the following: The iodine-deficient thyroid gland clears iodide from the blood more rapidly than does the gland of a patient supplied with an abundance of iodine. The rate at which thyroid hormone is being secreted is about the same for the Mendoza patients and for euthyroid subjects in areas of iodine abundance. In accordance with these findings, most of the Mendoza patients showed serum-protein–bound iodine concentrations within the accepted normal range. The wealth of information obtained by the Andean Goiter Expedition cannot be summarized briefly. Suffice it to say that new light has been shed on the adaptability of the thyroid gland to a lack of iodine in the diet. In addition to solving the main problem outlined above, this research has added in many ways to our knowledge of thyroid physiology.

To recommend this book only to endocrinologists seems unfair. The Harvard monograph should appeal to every biologist regardless of his or her special field of interest. I would like to see it read by every graduate student of the biological sciences because of its rare combination of excellent field-work, careful choice of techniques, and thoughtful interpretation of results—in other words, of splendid teamwork.

WALTER FLEISCHMANN

MEDICAL USES OF CORTISONE. *Including Hydrocortison and Corticotropin.*

Edited by Francis D. W. Lukens. The Blakiston Company, New York. $7.50. xii + 534 pp. 1954.

Some 29 contributors prepared 15 sections of this compendium dealing with the physiology, pharmacology, and therapeutic uses of the adrenocortical hormone in man. The following aspects are very adequately covered: Physiology of the Adrenal Cortex, (Russell and Wilhelmi); Pharmacologic Aspects of Adrenocortical Hormones in Man, and their Effects in Adrenal Insufficiency (Thorn, Jenkins, Laidlaw, Goetz, Dingman, Arons, Streeten and McCracken); Rheumatoid Arthritis and Other Rheumatic or Articular Diseases (Hench and Ward); Rheumatic Fever (Bunim); Other Collagen Diseases (Baehr and Levitt); Asthma and Rhinitis (Rose); Allergic Reactions to Therapeutic Agents (Harvey); Diseases Affecting the Skin (Pillsbury and Urbach); Granulomas: Pulmonary Granulomatoses, Pulmonary Fibrosis, Other Pulmonary Conditions (Richards and McClement); Infections (Keefer); Eye Diseases (Woods); Gastrointestinal Diseases (Machella); Blood Diseases and Malignancy (Bethell); Diseases of the Kidney (Luetscher, Jr.); Neuropsychiatric Disorders (Cobb). The subject index here is very adequate. This should be a valuable addition to a clinical endocrinologists's library.

DAVID B. TYLER

HEART. *A Physiologic and Clinical Study of Cardiovascular Diseases. Second Edition.*

By Aldo A. Luisada; foreword by Herrman L. Blumgart. The Williams & Wilkins Company, Baltimore. $15.00. xiv + 680 pp.; ill. 1954.

This second edition (1st ed., *Q.R.B.*, 25: 253. 1950) of a most comprehensive treatise should be in the library of all cardiologists. To this edition there have been added 3 new chapters: Cardiovascular Syphilis; Prognosis of Cardiovascular Diseases; and the Social and Legal Aspects of Heart Disease. Many of the other chapters have been completely rewritten or revised and modified. The book has an excellent combined author-subject index and an extensive bibliography.

DAVID B. TYLER

CORONARY HEART DISEASE IN YOUNG ADULTS. *A Multidisciplinary Study.*

By Menard M. Gertler and Paul D. White; with the aid, advice, and editorial assistance of E. F. Bland, J. Fertig, S. M. Garn, J. Lerman, S. A. Levine, H. B. Sprague, and N. C. Turner. Published for The Commonwealth Fund by the Harvard University Press, Cambridge. $5.00. xviii + 218 pp.; ill. 1954.

This volume brings a fresh approach to the problem of coronary artery disease which will be of great interest to physicians, particularly general practitioners, internists, and cardiologists, to those interested in preventive medicine, and to research workers in the field of cardiovascular disease. Starting with a group of 100 adults each of whom had survived an attack of myocardial infarction occurring before the age of 40, the authors have conducted a many-sided study designed to throw light on what *kind* of an individual is liable to sustain such an attack. The appraisal of each patient includes clinical, endocrine, morphological, and familial studies. Information has also been obtained concerning diet, intake of tobacco and alcohol, and athletic activity. Similar observations have been made on two control groups, one "matched" and the other "unmatched."

Of the 100 patients, only 3 were women. Almost all of the coronary patients appeared to be at least a decade older than their chronological ages; otherwise, no unusual clinical features were found. While no definite hereditary pattern could be identified, there was more coronary heart disease among the parents and siblings of the coronary group than among the parents and siblings of the unmatched control group. In physique individuals of the coronary group were shorter and broader than those of the control group, and showed a predominance of endomorphic mesomorphs. Physically more masculine than the unmatched control group, the coronary patients showed more typically feminine psychological attitudes than did the control group. The level of serum total cholesterol for the coronary group was increased over the control levels, and this held true for each physique, reaching its highest value in the coronary mesomorph in contrast to the lowest value in the control ectomorph. The level of serum uric acid was higher in the coronary group than in the control group, but the difference was statistically significant for only one type of physique: the endomorphic.

By including a series of photographs illustrating the variety of somatotypes found in the coronary heart disease group, together with a discussion of the somatotype method of Sheldon, the book brings the importance of constitutional medicine again to the fore. There are five appendices; summaries of the individual hereditary data and clinical histories are included, but there is no tabulation of the individual findings for the other factors studied. This seems to be a serious omission, particularly because the authors themselves have made little attempt to demonstrate cross-correlations between the variables under consideration.

CAROLINE BEDELL THOMAS

PHYSIOLOGY IN DISEASES OF THE HEART AND LUNGS. *Revised Edition.*

By M. D. Altschule. Harvard University Press, Cambridge. $7.50. xvi + 554 pp. 1954.

This is a revised edition of a well written and well or-

ganized book (*Q. R. B.*, 25: 241. 1950) designed primarily for use by third and fourth year medical students, whenever they may encounter some perplexing or unusual clinical conditions involving the heart or lungs. It is required, of course, that they at least possess inquisitive and mature enough minds to seek information concerning the phenomena that bother them. Altschule has summarized here some of the more significant literature dealing with the known mechanisms and physiological changes that accompany chronic cardiac decompensation, acute pulmonary edema—cardiac asthma, angina pectoris—myocardial infarction, cardiac arrhythmias, pericarditis, congenital and acquired cardiac defects, pulmonary fibrosis, chronic pulmonary emphysema, bronchial asthma, pleural effusion, and pneumothorax and pneumonia.

The book is not wanting in an extensive bibliography. In fact, some sections devote much more space to listing the literature than to a discussion of it. However, the volume is not designed for the specialist but primarily for the medical student who may hunger for knowledge, and reading it should further stimulate his appetite.

DAVID B. TYLER

ACUTE RENAL FAILURE.

By Arthur Grollman. Charles C Thomas, Springfield, Ill. $4.00. xii + 92 pp.; ill. 1954.

The late Tom Addis once lamented that "the only thing we know for certain about the kidney is that it makes urine." Definite progress has been made since then in the elucidation of the complex mechanisms involved in renal function. Such knowledge has been of considerable value in the treatment of one of the most difficult of clinical problems—the patient whose kidneys no longer make any urine at all.

This problem is the burden of Grollman's monograph. In the first half, the etiology, pathology, and disordered physiology are discussed. In the second half, the clinical course and the modifications which the physician can achieve in this course are examined. In many cases, full recovery of renal function will occur, but the secondary effects of the renal failure, particularly the electrolyte disorders, must be overcome. To this end a number of artificial kidneys, in effect dialyzing machines, have been designed and used; these aid in the maintenance of a more normal composition of the internal environment but are complicated and expensive and require trained personnel for their successful operation. Grollman advocates instead intermittent peritoneal lavage as a simple and effective means of restoring the disturbed electrolyte picture.

While primarily of interest to clinicians, this monograph will appraise biochemists and physiologists of one of the problems that their students will have to face in later years and of the importance of their basic disciplines to its successful clinical management.

F. P. CHINARD

BIOCHEMISTRY OF CANCER. *Second Edition.*

By Jesse P. Greenstein. Academic Press, New York. $12.00. xiv + 654 pp.; ill. 1954.

This second edition has been revised with considerable attention to the intrinsic and extrinsic factors in the induction of cancer and to recent attempts to control induction. The chapters on the chemical properties of the tumor and the tumor-bearing host have been brought up to date by the inclusion of much of the new literature published up to 1954.

DAVID B. TYLER

ADVANCES IN CANCER RESEARCH. *Volume II.*

Edited by Jessee P. Greenstein and Alexander Haddow. Academic Press, New York. $11.00. xii + 530 pp.; ill. 1954.

The second volume of this new series, like the first volume, is composed of 10 contributions. These cover the following aspects: The Reactions of Carcinogens with Macromolecules (Alexander), Chemical Constitution and Carcinogenic Activity (Badger), Carcinogenesis and Tumor Pathogenesis (Berenblum), Ionizing Radiations and Cancer (Brues), Survival and Preservation of Tumors in the Frozen State (Craigie), Energy and Nitrogen Metabolism in Cancer (Fenninger and Mider), Some Aspects of the Clinical Use of Nitrogen Mustards (Klopp and Bateman), Genetic Studies in Experimental Cancer (Law), The Role of Viruses in the Production of Cancer (Guerin), and Experimental Cancer Chemotherapy (Stock).

DAVID B. TYLER

GRENZ RAY THERAPY. *Principles, Methods, Clinical Applications.*

By Gustav Bucky and Frank C. Combes. Springer Publishing Company, New York. $8.50. viii + 204 pp.; ill. 1954.

Bucky and Combes have collaborated to compile an excellent up-to-date book on the poorly understood subject of Grenz-ray therapy. It should be both an admirable textbook and reference for any physician interested in the field of dermatology and oncology.

Bucky has been associated with each stage of development of Grenz-ray therapy, and Combes has had vast experience with this method of irradiation as applied to dermatology.

This admirable book is divided into two parts: Part One deals with the principles of the Grenz-ray therapy

from its very beginning, through the physics of this type of radiation. There is an excellent chapter on the histological changes that will be seen in the skin during the use of Grenz irradiation. Part Two is divided into another 6 chapters, each dealing with the practice of Grenz-ray therapy. The special applications of Grenz-ray therapy in tropical diseases, oral lesions, ophthalmology, and dermatology are presented by experts in those fields.

The entire field of Grenz-ray therapy, from its origin, evolution, and application in clinical medicine, is extremely well presented in such a manner that one cannot help but be struck by the potentialities of this relatively new addition to the armamentarium of the radiologist. The book contains an excellent classified bibliography and a good clinical index for quick reference in the text.

ROBERT G. CHAMBERS

DIE NERVENKRANKHEITEN. *Lehrbuch der Neurologie In Two Parts.*

By George Schaltenbrand. Georg Thieme Verlag, Stuttgart; [Grune & Stratton, New York.] DM. 87.00. xx + 880 pp.; ill. 1951.

This volume of Schaltenbrand's *Lehrbuch der Neurologie* is a typical textbook of clinical neurology. There is nothing unusual about its format or contents. Newer concepts which have not yet become clinical dogma are not one of the author's concerns. The literature cited is not recent. The student and practitioner interested in clinical problems of the nervous system will in all likelihood find that this text will not serve to replace any of the existing sources with which he is already familiar.

R. G. GRENELL

FRONTAL LOBES AND SCHIZOPHRENIA. *Second Lobotomy Project of Boston Psychopathic Hospital.*

Edited by Milton Greenblatt and Harry C. Solomon. Springer Publishing Company, New York. $12.50. xii + 426 pp.; ill. 1953.

This well-printed and liberally illustrated volume is the cooperative product of a prodigiously diversified research team of 52 psychiatrists, neurosurgeons, neuropathologists, physiologists, psychologists, and social workers, 28 of whom are identified as contributing authors. It offers a wealth of detailed information regarding the behavioral, neurophysiological, and psychometric changes observed in a series of 116 lobotomized patients. Nearly two-thirds of them were chronic schizophrenics in the age group 25–44 years, who had failed to respond to other therapeutic methods and then were allocated at random to unilateral, bimedial, or full bilateral lobotomy. The clinical part of the work required less than two years (1949–1951).

In the first section of the book (14 chapters), a rather condensed discussion of the comparative anatomy and physiology of the frontal lobes is followed by comprehensive reports on the procedural aspects and preoperative results of the "multidiscipline" study. The responsivity of the autonomic nervous system was investigated in terms of the blood pressure reaction to mecholyl and by means of a newly developed polygraph capable of recording seven autonomic responses simultaneously. In a group of 35 patients, the discomfort-relief quotient was used as a measure of the relationship between tension and adjustment in schizophrenia.

The second part of the book (12 chapters) deals with the observed post-lobotomy changes in clinical symptomatology, emotional adjustment, and social behavior. In general psychiatric terms and after an observational period of one to two years, approximately one-half of the patients were classified as slightly or moderately improved (17 and 30 per cent, respectively), and another 27 per cent as showing marked improvement with or without symptom-freeness. The remaining cases were either unimproved (21 per cent) or worse than before the operation (5 per cent). According to Rorschach studies, psychotic phenomena remained demonstrable even in the improved cases.

As to the method of choice in frontal lobe surgery, the authors give preference to the bimedial type of lobotomy, especially in "epinephrine-like" states revealing a high degree of tension. The indication for unilateral lobotomy is believed to be limited to the paranoid type of schizophrenia and to call for selection of the non-dominant hemisphere.

The third part of the book is both the shortest (4 chapters) and the clearest, possibly because it has largely been contributed by the two editors themselves. Of the theories presented with regard to predictive criteria and specified frontal lobe functions in disordered behavior patterns, of particular biological interest is the concept of lobotomy as being "almost specific" in reducing emotional tension, but having little or no direct effect on personality disorganization. Only if tension is high is a surgically created defect state (loss of cells and circuits) assumed to be able to reduce disorganization and to facilitate a new orientation to society through the lowering of tension. A "possible common mechanism for diverse forms of emotional disorder" is seen in an overactivity of circuits, keeping alive "the tension produced when instinctive demands are frustrated." On the other hand, the validity of the genetic theory of schizophrenia and other endogenous types of psychosis is acknowledged—perhaps a bit too casually—by the statement that "in predisposed individuals, the theory supposes that the persistence of excitation at the abnormal level leads to a general disorganization of func-

tion, so that contact with reality is altered, productivity and social capacity impaired."

FRANZ J. KALLMANN

MATERNAL DEPENDENCY AND SCHIZOPHRENIA: *Mothers and Daughters in a Therapeutic Group. A Group-Analytic Study.*

By Joseph Abrahams and Edith Varon. International Universities Press, New York. $4.00. 240 pp. 1953.

This is a report of a research project done at St. Elizabeth's Hospital under contract with the Veterans Administration in their Group Psychotherapy Research Program. It is a factual reporting of an interesting idea, namely, that of bringing the mothers of hospitalized schizophrenic young women together with their daughters in a series of group therapy sessions. The idea was a good one because it gave an opportunity to see in actual statu nascendi the workings of the interrelationships of mothers and daughters in this special situation instead of basing the judgments on historical material. Two things shine out throughout the report, viz., the hostility of the daughters for the mothers, and the mothers' dependence on the sickness of the daughters as a device to feel superior. As Florence Powdermaker, the general supervisor of the project, states in her Preface, it is as if such a mother has so little sense of the self that she can't relate herself as an adult to another adult, but clings to her husband as a dependent child, and can only feel that she exists if her own child remains completely dependent.

The authors are modest in their conclusions. They consider it likely that the girls were significantly different from most other girls from an early age, but they believe that the environmental experience of these girls, expressed as nurture at the hands of their mothers, was the more significant factor. They offer no clues why these children, and not the other children, became ill. They believe that most of the mothers gained some sense of improvement and better management of their interpersonal relationships with the daughters and with the husbands through their group therapy sessions.

It is unfortunate that such an interesting project should be marred for the general reader by a clumsy, cumbersome reporting method. Maybe this could not be avoided. Maybe it is equally important to report not only what mothers and daughters said and did, but also the running comments of the observer. To me, however, the comments seemed rather far-fetched and strained at times. Yet this is not the principal drawback of this book. The main problem for the reader is the unwieldy "officialese" in which it is written. Take, for example, the following: "This work has merely introduced the investigation of the problems of the members of the family in which there is emotional illness. The participation of the others in the family gestalt needs to be gone into. Identification of the intrapsychic as well as interpersonal mechanisms through concomitant individual and group analysis is highly indicated, for potentiation of therapeutic results as well as for more detailed information. Simultaneous sociological and anthropological study of these families is indicated, with comparative studies of families drawn from different social and cultural milieus. These studies could with profit be conducted along the lines of the present one, but for an entire (household) family, meeting in therapy regularly." How much easier it would be to say what the authors are trying to say in this paragraph in simple language understandable to everyone and without recourse to such multisyllabic monstrosities. Throughout the text runs this kind of jargon, which, to my mind, obscures the material instead of bringing it into clearer focus—and I am not unfamiliar with this jargon myself. There is so much use of adjectival description in the interpretation that it reaches the ridiculous at times. For instance, the daughter "used an erudite tone to speak of fecal material." In all honesty, I would like a definition of "an erudite tone." Also, (again the daughter) "received the caresses and attention passively and occasionally responded in kind with blank eyes and an animal-like expression on her face." "The daughter at times made open sexual love to other patients." (Is "love" the right word here?) Or about another daughter: "At times is well-dressed, appropriate to her age, mostly dressed in the most nondescript clothes leaving her buttocks bare." (It defies my imagination as to how she could accomplish this.)

We need more bright ideas of this sort and adequate research into them, but we also need very badly someone to put the material into readable English, which means what it says and nothing more, and in a literary style that will encourage the reader to read from the first word to the last instead of making it virtually impossible for him to do so.

WENDELL MUNCIE

ENCYCLOPEDIA OF ABERRATIONS. *A Psychiatric Handbook.*

Edited by Edward Podolsky; with a Foreword by Alexandra Adler. Philosophical Library, New York. $10.00. x + 550 pp. 1953.

This is one of the most amazing books it has been both my good and my bad fortune to read for review. It is, in the last analysis, an anthology of a number of outstanding articles on a surprising array of psychiatric subjects. The periodical of publication is identified after each paper, but neither year nor volume number is listed, and page references are not included. This must be considered a serious weakness. So is lack of definition of what is meant by the term "Aberrations." These seem to include practically every psychopathological phenomenon so far described in the literature. Authori-

tative articles, all of which merit serious study, are included, for instance, on a range of subjects so wide as practically to constitute a textbook on both Abnormal Psychology and Dynamic Psychiatry. Among others, papers alphabetized under the headings of Accident-Prone Behavior, Dynamics in (LeShan), Alcoholism, Chronic (Sillman), Amnestic Syndrome (Lidz), Body Image, Disorientation of (Teicher), Ecstasy, Artificial (Meerloo), Group Behavior, Non-Adaptive (Mintz), Hair-Plucking, Psychopathology of (Barahal), Lying (Karpman), Murder, Psychological Study of (Bromberg), Post-Orgastic Emptiness, Fear of (Agoston), Schizophrenic Process, Nature of (Jenkins) and Waking and Sleeping, Peculiar Intermediary State between (Foreschels) are all exceedingly thought-provoking and stimulating.

A number of articles deal with what for want of a better term is generally characterized as Social Psychiatry. Those on Anti-Semitic Attitudes (Ackerman and Jahoda), Alcoholism, Etiology of (Williams), Anti-social Behavior, Psychosomatic Disorders and Their Significance in (Abrahamsen), as well as the large number of papers dealing with drug addiction, juvenile delinquency, and the criminoses, raise theoretical and practical questions of prime importance. Their value is enhanced by the emphasis placed on legal implications.

In addition to articles of the type already listed, there is a large number of alphabetized definitions, some rather lengthy, of unfamiliar or unusual pedantic terms that most psychiatrists have long since discarded, and that despite their knowledge of Greek: these include words like *aichmophobia*, *amaxophobia*, *contrectation*, *ochlophobia*, *sophomania*, and the like. Most authors today would write "psychic impotence" instead of "aphanisis"; "fellatio" instead of "irrumation"; and "shoe fetishism" instead of "retifism." And for those who are studying articles of historical importance written years ago, the *Psychiatric Dictionary* by Hinsie and Shatzky contains many more terms, and defines them much more completely and much more authoritatively. One therefore wonders why such a space-filler has been incorporated in an anthology of this type.

This brings us immediately to the problem of the audience towards whom this *Encyclopedia of Aberrations* is directed. Aside from the fact that articles are listed in alphabetical order and deal with an almost encyclopedic list of subjects in the general fields of abnormal behavior and psychopathology, there seems to be no underlying theme—or even group of themes—which would make it possible to determine this. It is this in fact which, along with the lack of a usable index, must be considered the prime weakness of this book.

The anthologized articles are without exception significant, important, thought-provoking and stimulating. Colleagues who enjoy browsing through books can spend profitable hours studying them, and Podolsky has done a service in reprinting them in this volume. This anthology, however, would have been of much greater value to the student of psychiatry, of abnormal psychology, of criminology, or of sociology if the author had had in mind some single theme or group of themes—and had developed it (or them) in detail—when compiling his encyclopedia.

HAROLD ROSEN

THE INTERPERSONAL THEORY OF PSYCHIATRY.
By Harry Stack Sullivan; edited by Helen Swick Perry and Mary Ladd Gawel; Introduction by Mabel Blake Cohen. W. W. Norton & Company, New York. $5.00. xviii + 393 pp. 1953.

This is one of the most significant books, in the fields of dynamic psychiatry, abnormal psychology, and child development, so far published during the present decade. It concerns itself primarily with the developmental approach, is based upon recorded lectures delivered at the Washington School of Psychiatry during the winter of 1946–1947, is supplemented by material contained in the author's 1944–45 and 1946–47 notebooks outlining the lectures, and constitutes a rather comprehensive statement, in terms surprisingly understandable by the student of the subject, of Sullivan's dynamic concepts.

The first half of this book is devoted to a consideration of developmental epochs as such. In a number of chapters, Sullivan traces the emotional development of the infant, and in one exceedingly significant one he treats of The Infant as a Person. This can well be recommended for study to all students of personality dynamics. Other chapters are devoted to childhood, the juvenile area, pre-adolescence, early adolescence and, finally late adolescence. This last serves as a direct introduction to the third section of the book, entitled Patterns of Inadequate or Inappropriate Interpersonal Relations, in which Sullivan's well known research with the psychotic —and primarily the schizophrenic—patient is brought into sharp focus. His concepts are here brilliantly formulated.

As is well known, it was during the course of, and perhaps because of, his studies of schizophrenic patients that Sullivan became interested in those social tensions which he felt were contributory to, and basic for, the understanding of mental illness as such. This soon led him to the study of comparable factors that reflect themselves not only in the individual but on the international scene as well, and caused him to concentrate his considerable research ability on like problems inherent in international tensions as such. As a result, he helped found the World Federation for Mental Health, which he conceived, among other things, as an instrument for strengthening world peace. Since he died while attending its 1949 conference, it seems fitting that the concluding section of this book of his on *The Interpersonal Theory of Psychiatry*, entitled Towards a Psychi-

atry of Peoples, deals so completely with his social psychiatry.

The editors are to be congratulated on their thorough, scholarly, readable, well conceived and brilliantly executed task of presenting Sullivan's thoughts and theories to both the student and the mature psychiatrist. This work can be recommended as required reading for all workers in the field, be they psychiatrists, psychologists, or social workers—and the presentation is such, in addition, that it can be read with profit by the interested lay reader, with a college education but no first-hand knowledge of the subject, who wishes to broaden his background in one of the significant cultural disciplines of the present era.

HAROLD ROSEN

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE PSYCHOLOGY OF LEARNING.

By James Deese. McGraw-Hill Book Company, New York, Toronto, and London. $5.50. ix + 398 pp.; ill. 1952.

This textbook, planned for the advanced undergraduate in psychology, is also readable for students in other disciplines. Rather than placing an emphasis upon specific theories, it gives a broad coverage of current learning problems. These are documented with data from both animal and human research.

HARRY F. HARLOW

THE FOURTH MENTAL MEASUREMENTS YEARBOOK.

Edited by Oscar Krisen Buros. The Gryphon Press, Highland Park. $18.00. xxiv + 1163 pp. 1953.

This volume is an excellent reference book of tests and books on testing for educators, psychologists, counselors, and those in related professions. It presents the available commercial tests and many books on measurements with descriptions of the instruments and critical reviews of them. Although all tests and books are not reviewed, the number and selection of tests and books evaluated is comprehensive and complete. The reviews, for the most part, are frank and diversified. When two or more reviews are included, they frequently overlap, and may leave a person unfamiliar with the instruments somewhat in the dark as to whether the materials are or are not useful for their purposes.

Although this book is supplementary to the *Third Mental Measurements Yearbook*, it is sufficiently up-to-date and separate in its coverage to require its inclusion in the libraries of persons using tests. Thus, both as a reference encyclopedia and as a guide to principles of specific test functioning, this volume should be of value to anyone who must utilize or select tests.

DONALD MILMAN

OF WHALES AND MEN.

By R. B. Robertson. Alfred A. Knopf, New York. $4.50. xii + 300 pp. + 16 pl. 1954.

Potential readers of this book should not be frightened away by the knowledge that it is written by a psychiatrist, about his experiences while serving as the medical officer on a large modern Antarctic whaling expedition. Dr. Robertson turns his training to advantage as an author, and gives an exceedingly sympathetic and understanding account of the men and their life in such a whaling group. There is no condescension or detached observation here. In the Antarctic, living aboard and hunting whales from the small catcher boats, "crocks, misfits and misanthropes" are more suited to the life than the stable family man who is more acceptable at home.

Life on the expedition is divided between that on the large factory ship, and on its attached fleet of catcher ships, the ones that actually hunt and kill the whales. Robertson has a chance to spend a day aboard a catcher while it is out on the hunt. He describes Thor, captain and gunner (modern-day harpoonsman), formerly a New York taxi driver, but now the leading killer of the entire fleet. Like Thor, most of the people described in this book have a more vivid reality to the reader than ninety per cent of the characters found in current books.

Although the book is made up of a succession of interesting people and events, one man in particular stands out. Dornoch, a steward and good friend, makes an awkward call to the doctor's dispensary one night complaining of a sore ear. Although Dornoch gives a number of shy hints that he would like to talk, the sore ear is obviously made up, and he is dismissed, only to jump overboard later that night. It is only after the event that the full realization comes that the ostensible sick-call was really a disguised call for mental help.

ALAN D. CONGER

PSYCHOSOMATIC RESEARCH.

By Roy R. Grinker. W. W. Norton & Company, New York. $3.50. 208 pp. 1953.

This work on *Psychosomatic Research* is exactly what the blurb on the dust jacket characterizes it as being: a challenging appraisal of current psychosomatic concepts by one of the most active leaders in the field. In places it is exceedingly readable; in others, because of the complexity of the material with which it deals, it requires close attention and even closer study. It can nevertheless be considered recommended and even required reading for the psychiatrist, for his colleagues in the various medical specialties, and for the general practitioner as well.

The chapters on Historical Concepts and Current Conceptual Models are probably the two most significant from the viewpoint of the physician working di-

rectly with so-called psychosomatic disease. Together, they constitute a critical historical evaluation of the present status of the subject, defining it from variant angles of approach, emphasizing the necessity for multidisciplinary research, and formulating by definition and explanation a meaningful concept of what we today mean by the term—it must be stressed, by the very poor term—psychosomatics.

Because he so phrases it that no misconceptions can result, it would seem of value to quote directly from some of Grinker's formulations. Psychosomatic to him implies "a conceptual approach to *relationships*, not new physiological or psychological theories or new therapeutic approaches to illness" (p. 14). As he states, "Enthusiasm for the creation of a new specialty, widespread loose application of superficial psychological interpretations, and formulations of exclusively emotional etiology for somatic disturbances" must be considered "serious complications of wide and premature dissemination of tentative hypotheses" (p. 14).

Over and over again throughout the whole book, the fact is emphasized that it is not this but "the development and functioning of patterns of relationship among somatic and psychological systems that properly defines the psychosomatic study that is evolving in our time" (p. 28.). *Psychosomatic*, so he continues, "connotes more than a kind of illness; it is a comprehensive approach to the totality of an integrated process of transactions among many systems: somatic, psychic, social, and cultural. It deals with a living process that is born, matures, and develops through differentiation and successive stages of new forms of integration of parts and other wholes. It deals with stresses, strains, and adjustments, with acute emergency mechanisms, disintegrations, and chronic defensive states or disease. In fact, 'psychosomatic' refers not to physiology or pathophysiology, not to psychology or psychopathology, but to a concept of process among all living systems and their social and cultural elaborations."

The book develops this thesis in detail. The comprehensive scope of the material incorporated in it; the author's exceedingly challenging statements; the wealth of incidental, meaningful illustrative medical, psychiatric, physiological, and psychological material—all can well lead one to consider this work as a minor classic. It can be unqualifiedly recommended for reading by all those interested not only in the medical but the biological sciences as well.

The index, unfortunately, needs expanding. One will look in vain for items like *multiple sclerosis* or *asthma*, for instance, although *peptic ulcer*, which is discussed at no greater length than either of these, is indexed. This is so minor a criticism, however, that to pursue it further would amount to carping.

HAROLD ROSEN

DRIVES, AFFECTS, BEHAVIOR.

Edited by Rudolph M. Loewenstein. Editorial Board: Edward L. Bibring, Anna Freud, Heinz Hartman, Robert P. Knight, Ernst Kris, and Daniel Lagache. International Universities Press, New York. $7.50. 399 pp. 1953.

This is a series of essays in honor of Marie Bonaparte. The papers deal with a variety of problems within the sphere of psychoanalytic theory and method, as presented by a group of authorities in this field. It is stated that it is not the goal of this volume to present the psychoanalytic theory of human behavior in a systematic fashion. Each of the papers is considered as a significant contribution to psychoanalytic knowledge, and they are bound together only in so far as they are all based on the same basic tenets which attempt to explain the developmental relationship of the individual and his environment.

The first section of the book deals with psychoanalytic theory; a second group of papers is concerned with the relationship of the so-called "instinctual drives" to certain problems of education, social and cultural issues, anthropology and evolution. It will be apparent that a wide variety of special cases and problems must of necessity be brought into such considerations, and so it is. Ernst Kris, Daniel Lagache, Raymond de Saussure, Phyllis Greenacre, Bertram Lewin, Anna Freud, Geza Roheim, and others present provocative essays on a variety of topics that includes anxiety, psychoanalytic procedures and experience, dreams, depression, aggression, polyandry, etc. Scattered through these thoughtful discussions—all of which, of course, are based on a psychoanalytic concept and background—one finds a few attempts to bring physiology into the conceptual framework; to relate sensory, afferent function to perception and efferent to aggression, for example. Many interesting problems of this nature, however, are not suggested. This is by no means the fault of the psychologist or psychoanalyst alone. Biologists, too, have been and are notoriously slow in placing their studies of living organisms in a behavioral framework. De Saussure, for example, asks some most interesting questions in this regard. From what point in the evolution of living beings is there an autonomic nervous system in control of the system of invaginations? Beginning with what creatures is it possible to find hyperesthesia accompanying invagination? Can one observe a relationship between the development of the female sexual organs and the sensory nervous system? Is there a difference, peripheral or central or both, in the nervous structures and connections of the clitoris and vagina? Since psycho-physiological behavior patterns repeat themselves through development or regression, many questions can be asked concerning the relationship of anatomo-physiological constructions to psychoanalytic hypothesis. It is, perhaps, easier to see these relationships in some problems—the psychosomatic area, for instance—than in others.

It would be impossible, in a review, to discuss any, or all, such concepts at length. Suffice it to say that many of them are presented in this most interesting volume, by some of the foremost psychoanalytic thinkers of our time. It should be of value to all those who are concerned with such problems.

R. G. GRENELL

EXISTENTIAL PSYCHOANALYSIS.

By Jean-Paul Sartre; translated and with an introduction by Hazel E. Barnes. Philosophical Library, New York. $4.75. viii + 275 pp. 1953.

Existential Psychoanalysis constitutes a well-organized and beautifully written attempt by a philosopher to criticize various psychoanalytic schools of thought and to posit what he feels to be the more complete, more meaningful, and more significant *existential* approach to—and synthesis of—the fundamental problems involved. This synthesis is based primarily on the concept of free will, pays lip service to the idea of a dynamic unconscious but actually denies it, and can be called psychoanalysis only if all previous technical definitions of the term, no matter how divergent, be cast into the limbo of forgotten waste-baskets. While this is an important work, it therefore nevertheless cannot be considered a meaningful discussion of dynamic psychiatry as such. The Introduction, by Hazel E. Barnes, on the hand, is a masterly critical and evaluating commentary on the material incorporated in the book, and can be recommended for reading by psychiatrists in the highest of possible terms.

This work, in its present form, is composed of two essays translated from Jean-Paul Sartre's major philosophical opus, *L'être et le néant* (Being and Nothingness): Bad Faith (Chapter Two of Part One) and Existential Psychoanalysis (Chapter Two of Part Four). Both are exceedingly thought-provoking. In both philosophy and belles-lettres, it must be stressed, this book stands in its own right. An evaluation of its philosophical and literary value, however, would be inappropriate in this periodical. So far as its psychologic implications are concerned, there are very specific weaknesses—and these are beautifully summarized by the translator in her 37-page significant introduction to the text.

Sartre's ontology is well known. Until the second decade of this century, philosophy and psychology were taught for the most part in the same college departments and by the same instructors and professors, and were considered to a large extent at least to be practically the same subject. This book in one sense stems from the philosophy-psychology tradition—or from an extension of it—that so characterized the work of the philosopher-psychologist of the early days of the present century.

It is more than this, however. Sartre's work, both literary and philosophical, shows that he has real feeling for human beings as such. He has profound insight into the motivational bases of human behavior. *The Scarlet Letter* by Nathaniel Hawthorne, Thomas Mann's *The Magic Mountain*, and the plays of William Shakespeare, among others, can be considered as recommended reading—in fact, as required reading—for the psychiatrist-in-training. *Existential Psychoanalysis* seems midway on the continuum on which these can be placed. It can, like them, be read with profit and enjoyment by both the psychologist and the psychiatrist, and for the same reason. It is dynamic, but not in the psychiatric sense of the word. It is, instead, a literary and philosophical work of prime importance, and as such can well be studied by physicians in all the medical specialties as part of their own cultural backgrounds, especially since it deals with organized and deeply considered reflections about the day-by-day material which the psychiatrist sees in the course of his clinical practice and with which the general practitioner is constantly confronted in his contact with patients.

Different psychiatrists of course have different materialistic or idealistic, religious and philosophical backgrounds. Some psychiatrists in all probability are existentialists. For them, this work—like everying else written by Jean-Paul Sartre—must be considered as required reading.

HAROLD ROSEN

THE YEARBOOK OF PSYCHOANALYSIS. *Volume 8. 1952.*

Managing Editor, Sandor Lorand; Editorial Board, Henry A. Bunker, Ernest Jones, Bertram D. Lewin, and C. P. Oberndorf. Collaborating Editors: Edward Bibring, Marie Bonaparte, G. Bose, Angel Garma, Edward Glover, Martin Grotjahn, Ives Hendrick, Willie Hoffer, Sylvan Keiser, J. Lampl-deGroot, Rudolph M. Lowenstein, Karl A. Menninger, William Needles, and Philipp Sarasin; Editorial Assistant, Lottie M. Maury. International Universities Press, New York. $7.50. 383 pp.; ill. 1953.

The current volume of the *Yearbook of Psychonalysis* continues the high order of the previous volumes in the selection of pertinent material from the psychoanalytic literature of the year. There are 24 contributions: the first 5 devoted essentially to historical material; the last 4 dealing with contributions of analysis to aesthetics and anthropology; and the remainder dealing essentially with theoretical formulations and some clinical material. The list of contributors is so noteworthy and the articles themselves so interesting that it would be only a measure of my own particular interests to pick out special ones for mention. Nevertheless, I believe Anna Freud's contribution of Psychoanalysis to Genetic Psychology, Ernst Kris' Ego Psychology and Interpretation in Psychoanalytic Therapy, and Clarence Obern-

dorf's Psychopathology of Work, should be especially mentioned. In the clinical field, Irving D. Harris' Characterological Significance of the Typical Anxiety Dreams and Sidney G. Margolin's The Behavior of the Stomach During Psychoanalysis should be mentioned especially.

This volume, with those preceding, is a very worthwhile reference work wherein the vast psychoanalytic literature is culled by experts for the benefit of the reader.

WENDELL MUNCIE

PSYCHOANALYTIC EXPLORATIONS IN ART.

By Ernst Kris. International Universities Press, New York. $7.50. 318 pp. 1952.

This is a collection of essays which have been previously published over a period of twenty years. The essays are independent though interconnected and do not pretend to give a systematic presentation of a psychoanalytic psychology of art. The author feels that such an effort would be premature. The original essay, called The Approaches to Art, has been expanded; otherwise the essays remain unchanged. The book is divided into five parts: an introductory part with two subheadings, Approaches to Art and The Image of The Artist; The Art of the The Insane; The Comic; Problems of Literary Criticism; The Psychology of Creative Processes. The artist and the psychoanalyst are said to deal with similar stuff, and it is the effort to understand this material and to apply the special tools of psychoanalysis which constitutes the justification for the title of the book. The author points, for instance, to the wide distribution of certain similar themes in artistic productions, and in the psychoanalytic material which has come to light under Freud's aegis, particularly during the period when the study of the id was dominant. The use of such tools was illustrated classically in Freud's essay on Leonardo da Vinci. Yet this study ended in a certain futility, as Freud himself admitted, since it yielded no understanding as to why Leonardo was fated to become the great creator. This is a problem which can be attacked only as an interaction of man's personality and his times, and impinges on ego psychology. About all that psychoanalytic material so far contributes points only in the direction of vocational choice.

The author states explicitly that we do not have tools at present to permit the investigation of the roots of gift or talent, to say nothing of genius. He points to the need for some information concerning the role of a specific endowment in determining the kind of life experiences, and vice versa. Psychoanalysis also has investigated the artist's imagination. Freud himself pointed out that artists seem to be able to do intuitively what the psychoanalyst does in a systematic way only. The author implies that the artist has some special capacity "of gaining easy access to id material without being overwhelmed by it, of retaining control over the primary process, and, perhaps specifically, of making rapid or at least appropriately rapid shifts in levels of psychic function." Freud, offering a general hypothesis concerning this capacity, speaks of a certain "flexibility of repression," and added: "a considerable increase in psychic capacity results from a predisposition dangerous in itself." He felt that protection against this danger lay in the function of the ego, particularly in its capacity for sublimation.

The word "art" in our civilization carries the specific meaning "an invitation to common experience in the mind." This is achieved through an aesthetic illusion serving a cathartic function, through which repressed emotions are brought under ego control through appropriate outlets. The aesthetic illusion promises safety in this process, it guarantees freedom from guilt since we as an audience are following another's fantasy. It allows the rise of feeling which otherwise might not be permitted. In short, art offers the opportunity for socially approved cathartic release. The audience's participation in art goes through a series of responses: (1) a recognition of familiar subject-matter; (2) the perceived and recognized subject becomes part of the spectator, the latter achieving a certain identification with the artist's model (Schilder has pointed to the kinesthetic aspects of this situation); and (3) a supplement to the first two by experiencing how the effect to which we reacted has come about. This constitutes essentially an identification with the artist. This whole sequence depends on the presence of the aesthetic illusion and will be impeded by both "overdistance" and "underdistance."

The process of artistic creation divides itself into two types. One is a feeling of being driven, with an experience of rapture, and with the conviction that an agent acts through the creator. In this type, there are many features in common with regressive processes. The second type is more like work. The author feels that the first type, called inspiration, is at work whenever art reaches a certain level. Psychoanalytic investigation shows that artistic creation depends on the importance of the public for the creator, if in no other way than that the creator identifies himself in part with his public. The artistic creations in the insane show that while productivity may be increased in the initial phases of psychotic states, in time stereotypy develops, i.e., the creations are for the artist alone without need for communication to others. The author postulates a final thesis: "The shifts in cathexis of mental energy which the work of art elicits or facilitates are, we believe, pleasurable in themselves. From the release of passion under the protection of the aesthetic illusion to the highly complex process of re-creation under the artist's guidance, a series of processes of psychic discharge take place, which could be differentiated from each other by the varieties and degrees of neutraliza-

tion of the energy discharged. All these processes, however, are controlled by the ego, and the degree of completeness of neutralization indicates the degree of ego autonomy."

As to the artist himself, history accords to the artist much the same position assumed by heroes, and here two viewpoints are to be distinguished. One regards the hero's youth as the prehistory of his life—a viewpoint which psychoanalysis has furthered. The second regards the hero's achievements as a child not as part of his history but as a premonition of his future. This is an older conception and rooted in mythical thinking, still present to an amazing degree in thinking other than scientific. The artistic production starts first with a magical identity of the production with the thing which it symbolizes, and the more firmly the belief in the magical identity, the less attention needs to be paid to its external attributes. This is in keeping with the belief in the artist's magical power. As a matter of fact, such activity had a good bit of the taboo about it. But, beginning about the 16th century, the belief in the divine inspiration of the artist gave way to a secularization of the concept, artistic genius being recognized as the artist's own inner voice. Still the artist enjoyed a special position in society, sometimes outside of society. Mystery still surrounds the lore concerning the artist's work; the work should not outlive him or the artist's life is so tied to his work that destruction of the work must be followed by his suicide; or the artist must kill himself upon the discovery of an error in his work. In short, the secularization of the origin of artistic inspiration has not deprived the artist and his creation of an air of mystery and of the inexplicable.

It will be noted that the author lives up to his announced intention of not offering a comprehensive thesis concerning artistic creation. He has attacked the problem from several angles, and these constitute interesting psychoanalytic observations of various facets of the total problem. All this makes exceedingly interesting reading. Whether the author has added anything new to the total knowledge of the artistic creative process, one might question. This may resolve itself only as a translation into psychoanalytic terms of facts long known and couched in other language.

There follow chapters on the artistic creations of the insane, The Psychology of Caricature, Ego Development And The Comic, Laughter As An Expressive Process, and several chapters on problems of literary criticism, including an analysis of Shakespeare's King Henry the Fourth, or at least of Prince Hal's problem.

Altogether, this is a useful compilation of psychoanalytic essays dealing with the creative process. In this sense, it is to be compared with a book published in 1947 by Robert B. Heywood of the University of Chicago, called *The Work of the Mind*, and containing contributions by Mortimer J. Adler, Heinrich Brüning, Marc Chagall, S. Chandrasekhar, Alfeo Faggi, J. W. Fulbright, Robert M. Hutchins, C. H. McIlwain, John von Neumann, Arnold Schoenberg, Yves R. Simon, and Frank Lloyd Wright. In this latter volume, the creative process, designated as "work," is presented by inspired craftsmen in several fields in language adaptable to their own fields. I myself gained a greater sense of vital contribution from the latter volume than from that of Kris. Perhaps the monotony of the psychoanalytic terminology is in part responsible for this.

WENDELL MUNCIE

HUMAN BIOLOGY

SEXUAL HARMONY IN MARRIAGE.

By Oliver M. Butterfield; introduction by Nadina Kavinoky. Emerson Books, New York. $1.50. xiv + 82 pp.; ill. 1953.

This small manual is informative and accurate. Furthermore, it is written in a dignified manner by a representative of the clergy who has had considerable experience in writing and teaching on such matters, and it compares favorably with the larger, more complete, and more expensive volume of Van der Waal. For the uninitiated, here is a book at a lower initiation fee. It is less lyrical and less complete.

Butterfield, while stressing the anatomical, physiological, and technical aspects of sexual relations, does not neglect the overall personality reactions and the possible need for special professional help with certain types of problems. He has written the book with the assistance and collaboration of a gynecologist, Kavinoky, so as to give the book the authority of both religious and medical sanction. Scientifically, the reliance on Kinsey's statistics does not seem necessary nor entirely of value here. The overall impression is that this book is a competent manual, written clearly and with dignity.

WILLIAM T. DIXON

PROCEEDINGS OF THE SOCIETY FOR THE STUDY OF FERTILITY. *Number V. Liverpool Conference, 1953. W. Heffer & Sons, Cambridge.* 10s. (paper). ii + 106 pp. + 11 pl.; text ill. 1954.

An unusually interesting series of papers relating to problems of infertility was presented at the Liverpool Conference. These relatively short *Proceedings* include the pertinent results and commentary of 18 British investigators and of one French scientist (Brochart), whose work, however, was done in England.

The 16 papers touch on a wide range of subjects—from F. P. Lisowski's description of the vascularization of the rat ovary to G. I. M. Swyer's summary of the beneficial effects of testosterone implants on human spermatogenesis; from D. P. Alexander and J. F. D. Fraser's interesting note concerning reproductive vari-

ability in wild rodents to B. Sandler's critical study of the mechanism of tubal spasm in women; from M. Brochart's correlation of sperm maturation with permeability to eosin dye to A. C. Crooke and W. R. Butt's discussion of the effect of steroids on urinary gonadotrophic output; from M. H. Jackson's report of the suitability of Pantopaque as a contrast medium for hysterosalpingography to A. S. Parkes' thoughtful review on the desirability of and difficulties in the quest for an ideal contraceptive. Two areas received particular emphasis: studies of tubal patency in the human female (T. N. A. Jeffcoate, B. Sandler) and investigations of vasoligation and tubular constriction in the epididymis and seminal vesicles of the rat and man (E. J. Clegg, R. G. Harrison).

While considerable skepticism is evidenced by several contributors concerning the current understanding and treatment of various types of infertility disorders, psychological and cerebral factors have been elevated to an important position. Nature, time, and common sense have been given due credit for the favorable responses (i.e. conception) of many individuals who had previously suffered from involuntary sterility. On the other hand, certain suspected derangments, notably the post-pubertal occurrence of mumps orchitis (D. Young), were rather effectively dismissed as factors contributing significantly to male sterility.

DAVID W. BISHOP

PREGNANCY WASTAGE. *Proceedings of a Conference Sponsored by the Committee on Human Reproduction, National Research Council, in behalf of the National Committee on Maternal Health, Inc.*

Edited by Earl T. Engle. Charles C Thomas, Springfield, Ill. $8.50. viii + 254 pp.; ill. 1953.

Following close on their remarkable accomplishments in the management of late pregnancy, delivery, and early infancy that have helped reduce maternal mortality from 6 per 1000 births, only 15 or 20 years ago, to less than 1 per 1000 today, and infant deaths under one year of age from 65 to the present rate of 25 per 1000 births, scientists and clinicians have now turned their attention to the events of early pregnancy. Inability to conceive accounts for some barrenness, but most of the signs point toward loss of fetus early in pregnancy as the factor chiefly responsible for the 20 per cent of marriages that are childless. This factor also may hold family size below the number desired.

The title of this symposium refers to the loss of the fetus at any stage after fertilization and before viable maturity. However, the subject matter actually ranges from fertilization throughout pregnancy and into the first weeks after birth. The 17 articles, by distinguished scientists too numerous to name in this review, begin by suggesting that about 50 per cent of abnormal or retarded embryos in monkeys are due to constitutional defects, with the remainder due probably to failure of the corpus luteum. Other studies show that when domestic animals are mated, only 10 per cent or so fail to conceive, but nearly 40 per cent terminate in embryonic death. In certain animals, the older the gamete at the time of fertilization the less likely the embryo is to survive, and it is suggested this may be the case in man. Evidence is presented to incriminate hormonally controlled disorders of the endometrium in some failures of embryonic implantation and growth, and cases of successful treatment are described. Basic studies on the enzymes present in the placenta, and of the biochemical reactions involved in growth and differentiation of the fetus are reported from one laboratory, and a series of discoveries on the contractile properties of uterine muscle from another. Other laboratory studies cast light on the biochemical complexes involved in the vascular hypertension accompanying the maternal toxemias that are an important cause of fetal death, and still others indicate an increased production of adrenal steroids in pregnancy, possibly by the placenta. Although the participants in the conference do not become very excited about it, a rather good case is made for some fetal deaths being due to isoimmunization of the mother by A and B blood antigens, as well as the Rh antigens.

The remainder of the symposium is devoted to epidemiologic and clinical studes of abortion, stillbirths, and neonatal deaths. Considerable attention is given to the sharply increased mortality in the small but significant number of "post-mature" infants born more than a few days beyond the usual 280 days gestation, suggesting the need for a good test to determine the stage of pregnancy with a view to inducing labor at the optimal time. With regard to premature infants, the key to further reductions of mortality seems at present to lie in postponing delivery, but very little success has been achieved as yet.

This book, which is to be highly recommended, has something for laboratory scientists, clinicians, and public health specialists particularly, and for those interested in general biology as well as embryology and the physiology of reproduction. One might wish that the various findings reported in this symposium had been tied together by a single comprehensive review article, but most of the work is too far toward the frontiers of the subject and deals with too many unsettled problems to warrant systematization at this time.

PAUL A. LEMBCKE

THE DISPOSAL OF THE DEAD.

By C. J. Polson, R. P. Brittain, and T. K. Marshall; edited by C. J. Polson. Philosophical Library, New York. $7.50. xii + 300 pp. 1953.

This book is a reference volume covering all the various aspects of disposal of the dead. A short historical intro-

duction is followed by a large section concerning the possible legal or "paper-work" details that might accompany a death in England or Scotland. Since local regulations and customs vary extensively, the information presented in this section frequently does not apply in the United States, and therefore, it is not of much use outside of Great Britain.

The next section is devoted to cremation. The authors show their feelings strongly here and campaign enthusiastically for cremation rather than burial. They include a short history, present the statutes and regulations, and also provide a thorough chapter on the principles and methods of cremation. One can even find addresses and statistics on crematoria in England and throughout many countries of the world.

Another section treats of burial of the dead. Here an enlightening chapter describes the customs and rites of different religious organizations. This topic is of general interest and should be useful to a large number of individuals who find themselves with responsibilities relating to deaths. Likewise, the chapters on exhumation, embalming, and funeral direction that go to complete the volume provide a body of worth-while information on this aspect of our culture. The book is written clearly and is remarkably inclusive.

RALPH M. KNISELEY

BIOMETRY

ELEMENTARY STATISTICS.

By Benton J. Underwood, Carl P. Duncan, Janet A. Taylor, and John W. Cotton. Appleton-Century-Crofts, New York. $3.25. x + 239 pp. 1954.

This textbook is designed primarily for students at the sophomore level who are taking a short course in statistics. It includes a chapter on Simple Analysis of Variance and also one on Chi Square, but the general emphasis is upon frequency distribution, graphic representation, variability, the normal distribution curve, sampling error, and experimental design. It is well written and can be used to an advantage by the group for which it is intended.

DAVID B. TYLER

STATISTICAL METHODS *in Educational and Psychological Research.*

By James E. Wert, Charles O. Neidt, and J. Stanley Ahmann. Appleton-Century-Crofts, New York. $5.00. viii + 436 pp.; ill. 1954.

This is an intermediate level textbook designed for students of psychology and education. There are 19 chapters, as follows: Classification and Presentation of Research Information; Measures of Central Tendency; Quartiles, Deciles, and Percentiles; Measures of Variability; Coefficient of Correlation; Classical Theory of Sampling; Statistical Inference—Estimation; Statistical Inference—Testing Hypotheses; Chi-Square; Analysis of Variance—Single Classification; Analysis of Variance—Multiple Classification; Analysis of Variance—Double Classification Correction for Disproportionality; Linear Regression; Serial Correlation and Discriminant Analysis; Nonlinear Regression; Other Techniques of Correlation Analysis; Statistical Techniques in Measurement; Analysis of Covariance; and Further Applications of Discriminant Analysis. An appendix contains 12 statistical tables commonly used in statistical work.

It is unlikely that any two instructors or authors will ever agree on what the ideal coverage should be for a year's course in statistics. This textbook, at any rate, has neglected curve fitting by the method of least squares—a technique of considerable usefulness to the experimenter—and likewise any discussion of nonparametric statistics. On the other hand, the text has two good chapters on the methods of discriminant analysis, a topic which is not yet generally found in elementary textbooks.

The text is so arranged that parts of it may be used for a one-term course, or the whole may be used for a full year's course. Although many of the techniques discussed are quite complicated, the authors' approach to the methods is so gradual that students with a minimum of advanced mathematics should be able to do very well. Minimum emphasis has been placed on the derivation of statistical equations; on the other hand, the authors make an attempt to leave the student with a genuine understanding of what the equations do. The illustrations are generally worked out in great detail. A point of view which I myself like is the heavy emphasis on the analysis of variance as an approach to the more conventional statistics. For example, multiple correlation is approached as an analysis of variance problem, and the conventional solution by way of zero-order and partial correlations is given secondary emphasis.

All in all, this book has a great many merits and deserves the serious consideration of instructors in this area.

A. CHAPANIS

ELEMENTS OF STATISTICS.

By H. C. Fryer. John Wiley & Sons, New York; Chapman & Hall, London. $4.75. viii + 262 pp.; ill. 1954.

This is an elementary textbook of probability and statistics. It has 7 chapters: History and Introduction; The Summarization of Sets of Data Involving One Type of Measurement; Elementary Probability; The Binomial and Normal Frequency Distributions; Sampling from Binomial Populations; Introductory Sampling Theory

for a Normal Population Involving only One Variable; and Linear Regression and Correlation. The fact that there are only seven chapters is a little misleading. Actually, all but the first are solidly packed and the text has more than enough material for the average one-term course in statistics.

The book was written for students who have had no more than a course in college algebra. Even with this restriction, however, large variations in style of writing and difficulty are possible. Fryer has a style which tends to be a little more difficult than average. In other respects, however, the textbook has much to commend it. The numerical illustrations are generally worked out in great detail, there is a heavy emphasis on the empirical validation of statistical equations, and an unusually large number of problems is provided for the student. These are drawn from extremely diverse areas—psychology, education, biology, agriculture, economics, and so on—and many of them are provided with answers. Students in the biological sciences will probably like the chapter on elementary probability, which makes extensive use of data on blood-typing to illustrate the principles involved. To sum up, then, this is a good introductory textbook in statistics—a bit on the difficult side—but generally suitable for students in the biological sciences.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

TIME COUNTS. *The Story of the Calendar.*
By Harold Watkins; foreword by Lord Merthyr. Philosophical Library, New York. $4.75. xii + 274 pp. + 4 pl. 1954.

The hope of the World Calendar Society is that in 1956 the Gregorian calendar will undergo a change to bring it into conformity with our mechanized and systematized society. Why is change needed? The reasons are many, and the arguments, when computed in dollars and cents (or pounds, francs, kronor, etc.), are sound, for wandering holidays and uneven quarters, months, and years impose a costly burden on any system where uniformity and simplicity are synonymous with efficiency and reduced costs. A desire for a uniform World Calendar is evident among governments and in business. Opposition comes largely from certain religious groups which consider that stabilizing the 365th day by intercalating it into a special 8-day week is against "divine law."

In presenting a case for the World Calendar, which would put regularity into this system, Watkins uses an historical approach in describing man's attempts at systematizing his time scale. Many changes and compromises have been made in the past, and the irregularities in the Gregorian calendar make it clear that only a major world-wide acceptance of a uniform calendar will undo these vagaries. The United States, through its United Nations representative, blocked consideration of the adoption of a World Calendar in 1949. 1956 will probably see its birth.

The reviewer, however, will experience a certain degree of personal regret should its adoption take place. Although one of Saturday's children, supposedly born to a life of labor, he was protected from undue labor by the fact that no one was aware of this unless they checked back to that certain day in 1911 to find out. The vagaries of the calendar afforded a measure of security. After the World Calendar is adopted, no child of Saturday will ever be able to escape.

C. P. SWANSON

BLAKISTON'S NEW GOULD MEDICAL DICTIONARY. *A modern comprehensive dictionary of the terms used in all branches of medicine and allied sciences, including medical physics and chemistry, dentistry, pharmacy, nursing, veterinary medicine, zoology and botany, as well as medicolegal terms; with illustrations and tables.*
Edited by Harold Wellington Jones, Normand L. Hoerr, and Arthur Osol; with the cooperation of an editorial board and 80 contributors. The Blakiston Company, New York and Toronto. $9.50. xxviii + 1294 pp. + 45 pl. 1953.

This is an up-to-date dictionary (see *Q. R. B.*, 25: 127. 1950), well illustrated, and containing new entries in all branches of medicine and its allied sciences. The user will be agreeably surprised to find this dictionary almost encyclopedic in scope. Particularly extensive treatment has been given to pharmacology and to enzymology. Drugs listed in some recent editions of the Pharmacopoeia, The National Formulary, New and Non-official Remedies, and the U. S. Dispensatory are defined. The illustrative material shows careful selection. It is heartily endorsed by General James S. Simmons (Ret.), Chauncey Leake, Morris Fishbein, Norman T. Kirk, John F. Fulton and

DAVID B. TYLER

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